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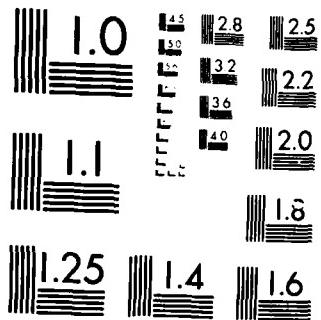
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# A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM

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NAVAL POSTGRADUATE SCHOOL  
Monterey, California

Rear Admiral R. H. Shumaker  
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Provost

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19 ABSTRACT (Continue on reverse if necessary and identify by block number) This report contains 232 summaries of research projects which were carried out under funding to the Naval Postgraduate School Research Program. This research was conducted under the areas of Computer Science, Mathematics, Administrative Sciences, Operations Research, National Security Affairs, Physics, Electrical and Computer Engineering, Meteorology, Aeronautics, Oceanography, and Mechanical Engineering. The table of contents identifies specifics research topics.												
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## INTRODUCTION

Research activities performed at the Naval Postgraduate School during the fiscal year 1984 are abstracted in this summary volume. These results are due to the efforts of principal investigators (faculty members of the school) with, in most cases, student contributions through activity leading to a thesis in pursuit of an advanced degree.

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The Naval Postgraduate School provides a unique interface between academic institutions and the U.S. Navy. As such, the research projects undertaken are, in general, clearly related to Navy and DoD interests. A substantially larger fraction of the R&D effort at NPS is in the exploratory development category than would be found in most universities. This is a result of student interests as well as faculty motivation created by the environment at NPS.

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**DEPARTMENT  
OF  
COMPUTER SCIENCE**

## DEPARTMENT OF COMPUTER SCIENCE

The Computer Science Department conducts research in all of the core areas of computer science: theory and analysis, programming languages and program development methodologies, database systems, artificial intelligence, operating systems and computer systems architecture. The following paragraphs highlight several projects in these areas:

### COMPUTER SOFTWARE DESIGN

Professor G. Bradley's research is in the area of software design. In particular he is interested in resolving the mismatch among cognitive, notational and constructive tools. In this area the constructive and notational tools have not been developed to support the current research ideas. Professor Bradley is especially interested in the design of medium sized scientific software projects. These projects typically involve one to three scientists and programmers and result in 5,000 to 10,000 lines of codes. Within DoD the execution of this kind of software represents a significant fraction of non-operational computation.

### SOFTWARE PORTABILITY

Professor Dan Davis is interested in the problem of improving the portability of the tools used to develop software for limited resource computer systems. He is attempting to identify abstractions at the theoretical level for the components of these systems. Professor Davis' immediate goal is to develop a set of functional abstractions that represent the basic resources of a PC system, and then to develop automatic programming development tools that can be used to generate experimental user interfaces for limited resource environments.

### DATABASE COMPUTERS

Professor David Hsiao's research investigates the future information utilization requirements of large organizations and the design and analysis of database computers to address those requirements. To this end he is studying the improvement of current technology and the use of emerging technology for prototyping the designs and for verifying the analysis of how database computers will meet these needs. Professor

implementation of prototyped components and verified algorithms. In addition, he is continuing and intensifying his research into benchmarking methodologies for the performance of database computers.

#### MULTI-COMPUTER OPERATING SYSTEMS

Professor Uno Kodres is directing a research effort in multi-computer operating systems. It is focused on supporting multi-computer based architectures with efficient use of event counts and sequencers. Professor Kodres is concentrating on event-count based systems because they consume significantly less resources than their competitors: message-passing and monitor based systems. It is anticipated that these real-time operating systems will be applicable to a wide variety of multi-computer architectures.

#### FIFTH GENERATION PROGRAMMING METHODOLOGIES

Professor B. MacLennan is investigating several different "fifth generation" programming methodologies. The primary goal is to decrease by an order of magnitude the number of lines of code needed to express an algorithm, thus producing a productivity increase comparable to that achieved in going from assembly language to higher-level languages. A secondary goal is to find new methods of programming that are appropriate to massively parallel computers. Professor MacLennan is concentrating on two new methodologies: functional programming, which makes use of higher-order functions (i.e., functions operating on other functions), and object-relationship programming, which makes use of a simulation-oriented programming paradigm based on forward chaining causal laws and non hierarchically-classified objects.

#### COMPUTER SYSTEM DESIGN AIDS

The main thrust of Professor A. Ross' work is the development of tools - computer programs that make it easier to design and test information systems. The primary emphasis is in making the tools easy to use and in making the tools so that they work well together. One of these tools is the Control System Design Language, which has been designed to ease the development of digital control systems by allowing the control engineer to specify his control problem in an abstract manner. Other tools include a set of design aids to assist in microprogramming and in testing and performance evaluation. Professor Ross has demonstrated some of these tools and is continuing to develop prototypes.

## ALTERNATIVE TO SAMPLING

Professor Neil Rowe has been developing an alternative to sampling for getting quick estimates of statistics on a database. The idea is to tabulate a small number of general-purpose statistics called a database in advance of user queries. It is then possible to infer answers to arbitrary queries by a large set of rules applied to the abstract. The answers are inferred "top-down" from other statistics, rather than "bottom-up" from samples. A partial implementation has been completed, and tests are underway to compare the system's performance to random sampling.

## ARCHITECTURES FOR REAL-TIME GRAPHICS

The goal of Professor Michael Zyda's research is to look at special purpose VLSI architectures for real time display generation. The goal of this work is the development of a methodology for taking a selected computer graphics algorithm and producing a silicon system that performs that algorithm. Part of this effort is the characterization of the changes in the architecture of the graphics display system made necessary by the addition of such real-time display generators. Several graphics algorithms that have the potential for VLSI implementation are being examined for their usefulness in real-time interactive applications and for their decomposability. Some of the algorithms being examined are (1) contour surface display generation, (2) realistic terrain generation using fractal geometry, (3) surface reconstruction from two-dimensional slices, and (4) realistic lighting generation using ray tracing techniques. The current hardware efforts with respect to this work are the design of a multibus compatible, single board version of the real-time contour surface display generator. The goal of this effort is to produce a working design for the contour surface display generator for insertion into the Silicon Graphics, Inc., IRIS graphics workstation.

Title: Methodology for the Formal Specification of Portable Software Interfaces

Investigator: Daniel L. Davis, Associate Professor of Computer Science

Sponsor: NPS Foundation Research Program

Objective: To develop a methodology for the abstract specification of computer system resources to facilitate the development of portable resource interfaces.

Summary: A major factor in the high cost of software is the lack of reusability and portability. In this research the methodology called "algebraic specification" has been adapted to the specification of physical resource abstractions in order to describe portable, implementation independent software interfaces. Such interfaces have been implemented before using ad hoc methods. The purpose of this work has been to work out a theoretical basis for such efforts.

A general methodology has been worked out using algebraic semantics. This methodology provides a formal theory of specification equivalence, adequacy, and computability. Also, it establishes a precise theory of implementation and formal correctness.

Complete specifications for an abstract, portable processor have been designed. A formal grammar for a specification language has been developed and an implementation of the abstract processor has been designed.

Title: Multi-backend Database System Architecture

Investigators: D. K. Hsiao, Professor and Chairman of Computer Science, D. S. Kerr, Adjunct Research Professor of Computer Science, P. Strawser, Adjunct Research Instructor of Computer Science, and S. Demurjian, Adjunct Research Instructor of Computer Science

Sponsor: Office Naval Research

Objective: To complete the prototyping of a multi-backend database system, to develop benchmarking methodologies for database system performance measurements, to apply the methodologies to the multi-backend system, and to verify its design claims in performance gains and capacity growth.

Summary: Final efforts by the implementors to complete the prototyped multi-backend database system have been made. The system is now operational and demonstrable. It can be used for benchmarking and testing purposes. Concurrent efforts have been made to develop a comprehensive methodology for benchmarking database system in general and the prototyped system in particular. To this end, the methodology has been applied to the system for checking its performance under various load conditions. Test data have been collected to verify the design claims or disclaims of the experimental system.

Publications:

R. D. Boyne, D. K. Hsiao, D. S. Kerr, A. Orooji, "A Message-Oriented Implementation of a Multi-Backend Database System (MBDS)," Database Machines, edited by H. O. Leilich and M. Missikoff, New York: Springer-Verlag, 1983.

R. Bogdanowicz, M. Crocker, D. K. Hsiao, C. Ryder, V. Stone, and P. Strawser, "Experiments in Benchmarking Relational Database Machines," Database Machines, edited by H. O. Leilich and M. Missikoff, New York: Springer-Verlag, 1983.

D. K. Hsiao and P. Strawser, "The Predicate Machine - A High-Level Database Computer," Proceedings of High-level Computer Architecture Conference, Los Angeles: University of Maryland, (May 1984).

S. A. Demurjian, D. K. Hsiao, D. S. Kerr and A. Orooji, "The Implementation of a Multi-Backend Database System (MBDS): Part IX - The Revised Concurrency Control and Directory Management Processes and the Revised Definitions of Inter-process and Inter-Computer Messages," Naval Postgraduate School Technical Report, NPS52-84-005, February 1984.

A. Orooji, D. S. Kerr, and D. K. Hsiao, "Software Engineering Techniques for Large-Scale Database Systems as Applied to the Implementation of A Multi-Backend Database System," Naval Postgraduate School Technical Report, NPS52-84-012, August 1984.

D. K. Hsiao, "Future Database Machine Architectures," Naval Postgraduate School Technical Report, NPS52-84-014, September 1984.

Conference  
Presentation:

D. K. Hsiao, "Database Education," IEEE Computer Society Conference on Data Engineering, Los Angeles, April 26.

D. K. Hsiao, "Future Database Machine Architectures," NYU Symposium on New Directions on Database Systems, New York, May 16, 1984.

D. K. Hsiao, "The Predicate Machines," The High-level Computer Architecture Conference, Los Angeles, May 21, 1984.

D. K. Hsiao, "Database Computers," IEEE Computer Society and NBS Conference on Database Trend and Application, Washington, D.C., May 22, 1984.

D. K. Hsiao, "Database Computers," Database '84 Colloquium, Naval Security Group, San Diego, CA, June 4, 1984.

- Theses Directed:**
- P. Strawser, "A Methodology for Benchmarking Relational Database Machines", Ph.D. in Computer Science, March 1984.
- G. Macy, "Design and Analysis of SQL Interface for a Multi-Backend Database System", Master's Thesis, March 1984.
- S. Muldar, "The Design and Analysis of Join and Ordering Operations for a Multi-Backend Database System", Master's Thesis, June 1984.
- R. Rollins, "Design and Analysis of a Complete Relational Interface for a Multi-Backend Database System", Master's Thesis, June 1984.
- D. Weishar, "Design and Analysis of a Complete Hierarchical Interface for a Multi-Backend Database System", Master's Thesis, June 1984.
- R. C. Tekampe and R. J. Watson, "Internal and External Performance Measurement Methodologies for Database Systems", Master's Thesis, June 1984.
- A. Ekici, "Design and Analysis of An Access Control Mechanism for the Multi-Backend Database System", Master's Thesis, June 1984.

Title: Programming Language Metrics

Investigator: B. J. MacLennan, Associate Professor of Computer Science

Sponsor: Office of Naval Research

Objective: This project involves research on three different fronts: (1) validation methods and epistemological foundations for programming language metrics, (2) theoretical definition and investigation of the properties of these metrics, and (3) practical tools for measuring programming languages. Progress has been made on all three fronts this year.

Summary: One of the major accomplishments of this year has been the development of a "software laboratory" for measuring properties of languages and programs. The intent is to have an assortment of useful measurement and analytical tools that can be connected in a variety of ways for different and evolving experimental purposes. The system includes:

- .SCANNER - breaking down texts
- .PERCENT - computing absolute and cumulative frequencies of tokens
- .IDAMAN - interactive data management
- .IDALOD - interactive data loading
- .STATI - interactive data analysis (descriptive and inferential statistics)
- .IDAGRA - interactive data analysis/graphics (linear regression and inferential statistics)
- .IDAFIT - interactive data analysis (nonlinear composite arbitrary functions) and graphics

This system was largely developed under contract with Dr. Daniel Guinier. It is implemented in standard FORTRAN 77 and runs on the VAX computer under VMS. Progress was also made on the

theoretical front. We have developed means for computing a number of information theoretic properties of languages and their grammars. For example: the entropy of a system of symbols is widely recognized as a measurement of that system's complexity and organization. We have determined how to compute in a simple way a language's entropy from a grammar annotated with production probabilities. We have also investigated the computation of other information theoretic properties of languages and grammars, such as the average information born by a symbol in the language and the average information used by the production of a grammar.

Finally we have investigated the validation of metrics like those defined above. We have determined that these metrics must be validated by their integration with existing theories and by their usefulness, rather than by psychological demonstrations of their relationships with perceived qualities. As it has in the natural sciences, the objective approach is more likely to produce testable, widely applicable theories than is the subjective method.

**Publications:**

B. J. MacLennan, "Functional Programming: Theory and Practice", forthcoming.

B. J. MacLennan, "Simple Metrics for Programming Languages", *Information Processing and Management*, pp. 1-2, 1984.

B. J. MacLennan, "Abstraction in the INTEL iAPX 432 Prototype Systems Implementation Language", *SIGPLAN Notices*, p. 12, December 1983.

B. J. MacLennan, "A View of Object-Oriented Programming", forthcoming.

B. J. MacLennan, "Concurrency and Sychronization in the Intel iAPX-432 Prototype Systems Implementation Language", NPS Technical Report, NPS-52-83-011, September 1983.

B. J. MacLennan, "Relational Programming", NPS Technical Report, NPS-52-83-012, September 1983.

B. J. MacLennan, "A Commentary on Mill's Logic Book I: Of Names and Propositions", NPS Technical Report, NPS-52-83-013, October 1983.

B. J. MacLennan, "A Simple Proof of a Generalized Church Rosser Theorem", NPS Technical Report, NPS-52-84-007, June 1984.

B. J. MacLennan, "Information-Theoretic Properties of Languages and Their Grammars", NPS Technical Report, NPS-52-84-010, August 1984.

B. J. MacLennan, "Tree Transformation for Functional Programming", NPS Technical Report, forthcoming.

B. J. MacLennan, "In What Sense is Computer Science a Science?", NPS Technical Report, forthcoming.

B. J. MacLennan, "The Four Forms of  $\Omega$  - Alternate Syntactic Forms of an Object Oriented Language", NPS Technical Report, forthcoming.

B. J. MacLennan, "A Simple Software Environment Based on Objects and Relations", NPS Technical Report, forthcoming.

Conference Presentations:

B. J. MacLennan, "Programming Environment Support for Software System Design", Software Engineering R&D Technology Review, 17-19

B. J. MacLennan, "An Object-Oriented Approach  
to Logic Programming", AL/Robotics Technology  
Review, 24-26 September 1984.

B. J. MacLennan, "On the Validation of Computer  
Science Theories", Second Symposium of the  
Empirical Foundations of Information and Software  
Science, 3-5 October 1984.

Title: Top-Down Reasoning About Statistics on Databases

Investigator: N. C. Rowe, Associate Professor of Computer Science

Sponsor: NPS Foundation Research Program

Objective: To develop a comprehensive alternative to sampling for estimating values of statistics on a database, using expert systems methodology from artificial intelligence.

Summary: After preliminary study, research was focussed on two areas of highest potential payoff in statistical estimation, estimation of sizes of set intersections and unions (because of its application to computer performance enhancement), and estimation of statistics on transformed variables from statistics on the original variables (because of the strong preliminary results obtained). Detailed theoretical investigation was done on both topics, and a number of new results were obtained. Computer experiments were then done to validate the formulae found, and did confirm them. The set intersection study was done in the computer language Prolog, and the variable transformation study was done in the language Interlisp, and this also provided an opportunity to evaluate the relative merits of two rather different languages for this type of research.

Publications:

N. C. Rowe, "Absolute Bounds on the Mean and Standard Deviation of Transformed Data for Constant-Derivative Transformations", Technical Report NPS52-84-006, Naval Postgraduate School, July 1984. Submitted to a journal.

N. C. Rowe, "Diophantine Inferences from Statistical Aggregates on Few-Valued Attributes", Proceedings of the International Conference on Data Engineering, Los Angeles, CA, April 1984, 107-110.

N. C. Rowe, "Antisampling for Estimation: An Overview". Submitted to a journal.

N. C. Rowe, "Absolute Bounds on Set Intersection and Union Sizes Using Precomputed Information", in progress.

Conference  
Presentations:

N. C. Rowe, "Antisampling for Estimation",  
Computer Science and Statistics: 16th Symposium  
on the Interface, Atlanta, GA, March 1984.

N. C. Rowe, "Inferences About Numbers",  
Artificial Intelligence/Robotics Technology  
Review, Naval Postgraduate School, Monterey, CA,  
September 1984.

Title: The Effects of Real-Time Display Generation on the Architecture of Graphics Display Systems

Investigator: Michael J. Zyda, Assistant Professor of Computer Science

Sponsor: NPS Foundation Research Program

Objective: The effects of special purpose VLSI architectures on the design of the graphics display system will be evaluated, with special attention to data input/output rates, human interaction, and currently available graphics display system functionality. Several graphics algorithms that have the potential for VLSI implementation will be identified and studied, with the goal being a characterization of the changes necessary in the architecture of the graphics display system required by VLSI based, real-time display generators.

Summary: From the 1st of July 1984 (the start of the research quarter for this proposal) until the 30th of September 1984, the following work has been carried out: The first objective of the study was to examine the proposed architecture of one real-time display generator, the contour surface display generator of [Zyda,1984a]. Part of this objective has been carried out in the form of three technical memoranda [Zyda,1984b], [Zyda,1984c], and [Zyda,1984d]. Part of these studies was the development of a modeling methodology for evaluating the physical parameters inherent to both the application, and the architecture. The second objective of the study was to examine the input and output parameters obtained from the system model in order to determine exactly how that display generator can be interfaced to a graphics display system. This study was held up due to the prolonged procurement process for the necessary equipment, a Silicon Graphics, Inc. IRIS-1400 Graphics Workstation. After having been ordered in late March 1984, the Graphics Workstation arrived finally on the 5th of October 1984. The third objective of the study was the identification of other graphics algorithms with the potential for implementation in VLSI. This work has begun through the efforts of two current thesis students. The studies being carried out are cursory examinations of these algorithms for their distributability among multiple processors. Part of these studies will be an attempt to determine if the changes proposed for the graphics system for the contour surface display generator are applicable to other real-time display generators.

Publications:

Zyda, Michael J., "The Feasibility of a Multi-processor for Real-Time Contour Surface Display Generation," Technical Report NPS52-84-xxx, Monterey, California: Department of Computer Science, Naval Postgraduate School, September 1984d (in preparation).

Zyda, Michael J., "Real Time Contour Surface Display Generation," Technical Report NPS52-84-013, Monterey, California: Department of Computer Science, Naval Postgraduate School, September 1984c.

Zyda, Michael J., "A Decomposable Algorithm for Contour Surface Display Generation," Technical Report NPS52-84-011, Monterey, California: Department of Computer Science, Naval Postgraduate School, August 1984b.

Zyda, Michael J., Algorithm Directed Architectures for Real-Time Surface Display Generation, D.S.c. Dissertation, Dept. of Computer Science, Washington Univ., St. Louis, Missouri, 1984a.

Theses Directed:

Gaddis, Michael E., "The Fractal Geometry of Nature: Its Mathematical Basis and Application to Computer Graphics", (forthcoming.)

Walker, Robert A., "A Methodology for Evaluating the Implementation of Multiprocessor Architectures for Real-Time Weapons Control Systems", (forthcoming.)

Sahintepe, Mustafa, "A Graph Theoretic Algorithm for Contour Display Generation", (forthcoming.)

Coomes, Ken, "The Use of VLSI for Real-Time Display Generation", (forthcoming.)

**DEPARTMENT  
OF  
MATHEMATICS**

## DEPARTMENT OF MATHEMATICS

Members of the Department of Mathematics are active in several areas and often in collaboration with faculty from other academic departments at NPS. Most current investigations are in applied mathematics topics, such as numerical analysis and numerical modeling, methodology, and game theory. In addition, the departmental microprocessor laboratory supports ongoing research on the applications of microprocessors both inside and outside of the classroom.

### NUMERICAL ANALYSIS AND NUMERICAL MODELING

This area continues to be a major, and still growing, focus for the research efforts of department members. R. H. Franke is currently studying questions in the approximation of surfaces from scattered data points, and has recently applied some of these techniques to the question of initialization of fields in numerical weather prediction models.

M. Hartman is currently working with Professor G. Cantin of the Mechanical Engineering Department on difficulties that arise in microcomputer implementation of nonlinear iteration schemes from structural analysis.

R. Mendez is pursuing ongoing research in computational fluid dynamics. Together with Professor Kunio Kawahara of the Institute of Space and Astronautical Science in Japan, he has developed a three dimensional vortex method that has been used to simulate compressible flow past a parachute. He is also conducting an ongoing investigation of the comparative performance of computational fluid dynamic programs on the new generation of supercomputers, such as the Cray XMP-48.

A. Schoenstadt continues a collaboration with faculty in the Departments of Meteorology and Mechanical Engineering in developing and refining finite element models for use in numerical weather prediction. Current investigations are directed to studying models with time-dependent, specified boundary conditions. Such models have application for limited geographical area forecasting.

## STATISTICAL ANALYSIS

T. Jayachandran, with Professor Larson of the Department of Operations Research, is conducting an ongoing program providing statistical support to the Air Force Oil Analysis Program. In addition, Professor Jayachandran has performed statistical analyses of the storm tracking methodology used by the Naval Environmental Prediction Research Facility.

## OPTIMIZATION

I. Russak in collaboration with Professor A. Goldstein of the University of Washington, is investigating optimization of functions using noisy values, a problem which has application to determining submarine transducer position.

## DISCRETE MATHEMATICS

H. Fredricksen is applying discrete mathematics to problems in communication, coding, and cryptology. Some of this work has been in collaboration with Professor Titus of the Department of Electrical and Computer Engineering.

## SIMULATION METHODOLOGY

A. Schoenstadt, in joint cooperation with Professors Hartman and Parry of the Department of Operations Research, is developing methodologies for Airland Battle Combat modeling. This effort focuses on applying a network oriented architecture and modern network optimization techniques in land combat simulation.

## GAME THEORY

G. Owen is studying various mechanisms used for the group pooling of information and for group decision making.

## MICROCOMPUTERS

G. Latta is investigating the problems of networking and communication and between different microcomputers and the mainframe computer. He has developed several communications programs currently used at NPS for this purpose.

Title: Objective Analysis of Meteorological Data

Investigator: R. H. Franke, Professor of Mathematics

Sponsor: Naval Environmental Research Prediction Facility

Objective: Study of schemes for combining observed data with numerical weather predictions for weather maps and initial conditions for next prediction cycle. This is a continuing project.

Summary: The error in the overall process of making corrections to a "first guess" field (from numerical predictions) based on the difference between the first guess and observed values has been decomposed into statistically independent terms. These three terms depend on (1) the underlying field to be analyzed and the grid-to-observation point interpolation scheme, (2) the observation errors and the observation point-to-grid interpolation scheme, and (3) the first guess error and both interpolation schemes. A simulation program was written and rms errors for various combinations of schemes obtained.

Publications: Richard Franke, "Sources of Error in Objective Analysis", NPS report NPS-53-84-0003, May 1984  
(Accepted for publication in Monthly Weather Review)

Title: Modelling of the Vortex Tracking Program Errors

Investigator: T. Jayachandran, Professor of Mathematics

Sponsor: Naval Environmental Prediction Research Facility

Objective: Perform a statistical analysis to evaluate the performance of the Systematic Error Identification System (SEIS) and the Vortex Tracking Program (VTP), when tracking weather systems.

Summary: The Naval Environmental Prediction Research Facility (NEPRF) has been using a new storm tracking methodology since 1983. Data on 80 storms tracked using this methodology to examine the forecast errors was subjected to an exploratory statistical analysis. The results indicate that the new methodology has improved the storm tracking Capability Preliminary Statistical Models to describe the forecast errors that have been developed.

Publications: "An Evaluation of the Performance of a New Storm Tracking Methodology", Technical Report NPS-53-84-0007.

Title: CEMS Enhancement of OAP

Investigators: T. Jayachandran, Professor of Mathematics and  
H. J. Larson, Professor of Operations Research

Sponsor: U. S. Air Force

Objective: The objectives of the project are (1) to monitor/evaluate the performance of an automated oil analysis procedure that is incorporated in the comprehensive engine management system (CEMS) and (2) to examine the behavior of oil analysis readings on a newly developed portable wear metal analysis (PWMA).

Summary: Based on the data using the automated evaluation procedure in CEMS, certain modifications to the statistical limits in the procedure have been recommended. Certain changes in the computer program have to improve the presentation of the results have been proposed. Participated in the development of an evaluation plan for a newly developed Portable Metal Analyzer (PWMA).

Publications: This is a continuing project and out recommendations on improving CEMS were communicated to the sponsor in a letter report. A formal report will be forthcoming.

Title: Research into Problems of Group Decision Theory and Information Pooling

Investigator: G. Owen, Professor of Mathematics

Sponsor: NPS Foundation Research Program

Objective: This was the beginning of a long-term research project designed to study several mechanisms used for the pooling of information and for making decisions in groups. The general objective is to give optimal (or at least good) methods of aggregation (in the sense of maximizing the probability of a correct decision).

Summary: Research in this phase of the project focused on (a) voting in deliberative bodies and (b) pari-mutuel betting systems. For (a), it was shown that, under certain circumstances, i.e. when certain members of the group tend to vote together, an indirect majority rule might well give better results than direct majority rule voting, and certain mixed (semi-proportional) systems might be better than either direct or indirect majority. For (b), it was shown that, at a race track, an equilibrium set of pari-mutuel odds will (under very broad conditions) exist, which in effect serves as a method of aggregating the individual bettors' probability estimates on the outcome of the race.

Publications: G. Owen, "Fair Indirect Majority Rules," in Aggregation of Opinions and Group Decisions, ed. G. Owen and B. Grofman, Reidel, forthcoming (late 1984).

G. Owen, "Pari-Mutuel as a System of Information Aggregation," Technical Report NPS 53-85-0001, Department of Mathematics, Naval Postgraduate School, October 1984.

Conference Presentations: The report "Fair Indirect Majority Rules" was presented at the annual meeting of the Public Choice Society, Phoenix, AZ, 28 March 1984, and at the Fifth Latin American Meeting of the Econometric Society, Bogota, Colombia, 24 July 1984.

Title: High Accuracy Position Determination of Transducers on a Submarine Hull

Investigators: I. B. Russak, Associate Professor of Mathematics, Naval Postgraduate School; A. A. Goldstein, Professor of Mathematics, University of Washington

Sponsor: Naval Undersea Warfare Engineering Station

Objective: Transducers have been placed on the hull of a submarine for the purpose of receiving acoustic signals to be used in calculating torpedo position during a test. It is essential that transducer positions be known very accurately to approximately a centimeter. Methods previously used at Keyport for this task have not yielded sufficient accuracy. The purpose of this task is to, if possible, describe a method which yields the desired accuracies.

Summary: Two methods are investigated - the first of these is given in the reference cited below (1) and the other developed by the authors. It is shown that: (a) for the expected level of noise in the data, the latter of these methods provides significantly smaller location errors than the former and (b) under optimal geometries defined herein, the desired accuracies are approached.

Publications: M. C. Young, "An Exact Solution to a Problem in Positioning", Journal of Inst. of Navigation, Vol. 20, #4, Winter 73-74.  
A. Goldstein, I. B. Russak, High Accuracy Position Determination of Submarine Hull Mounted Transducers - NPS 53 84-0008. "Optimal Geometry for Ship Triangularization", forthcoming.

Title: Development of Finite Element Prediction Model

Investigators: R. T. Williams, Professor Meteorology  
A. L. Schoenstadt, Associate Professor of Mathematics  
R. E. Newton, Professor of Mechanical Engineering

Sponsor: Naval Air Systems Command

Objective: To develop and test a finite element atmospheric prediction model.

Summary: The Canadian baroclinic finite element program was converted to run on the NPS IBM 3033. Cyclic boundary conditions were then installed in the barotropic version of this code. The required elliptic solvers were developed for variable boundary conditions.

Publications: R. E. Newton, "Use of the Tensor Product for Numerical Weather Prediction by the Finite Element Method, Parts I and II." Naval Postgraduate School Reports NPS-69-84-001 and NPS-69-84-005.

**DEPARTMENT  
OF  
ADMINISTRATIVE SCIENCES**

## DEPARTMENT OF ADMINISTRATIVE SCIENCES

The Department of Administrative Sciences is the Naval Postgraduate School's organizational unit responsible for academic programs designed to educate officers and DOD civilians in a variety of functional management specialities. As such, it is a large, multi-disciplinary department with diverse research projects oriented to support management tasks within the Navy and the Department of Defense. For description, the research program may be divided into the following (sometime overlapping) areas of research concentration: Acquisition, Information, and Logistics Systems; Financial/Resource Management; Manpower, Personnel and Training; and Organizational Sciences. The past year's focus of the specific research projects in these areas is summarized in the following paragraphs.

### AQUISITION, INFORMATION, AND LOGISTICS SYSTEMS

D. Boger, C. Jones, and K. Sontheimer (University of Pittsburgh) continued their research into the behavior of defense contractors and the peculiarities of this industry structure for the defense internal firm organization and financial performance. M. Kline continued his research in systems engineering and the systems acquisition process areas. N. Lyons began a project which will examine naval officers' need for improved knowledge and capability in problem-solving techniques and the potential for the use of computers and artificial intelligence to assist in meeting that need. N. Schneidewind continued his research in the areas of software engineering and management, and his involvement in the design of communications networks in support of Naval supply systems. A. McMasters, in conjunction with F. Richards (Operations Research Department), completed development and evaluation of a wholesale level initial provisioning model for the Naval Supply Systems Command. Professor McMasters also continued his research on methods to assist the Naval Electronics Systems Command in determining when to transfer inventory control of electronic items to the Ships Parts Control Center. Professor J. Creighton continued his research on the technology transfer process. D. Dolk continued his study of the applicability of artificial intelligence techniques to model management software in the operations research area. Professor Dolk also initiated a project to study data administration needs and software requirements for supporting the U.S. Army Military Personnel Center. Professor San Miguel examined the financing strategy used by DoN to obtain the services of ships. W. Cullin continued his applied work in support of DoD aquisition planning, production procurement, and R&D management.

D. Lamm and R. Schill studied the cost/effectiveness of Navy acquisition strategies during the production and deployment phases of major weapon systems aquisition process.

#### FINANCIAL-RESOURCE MANAGEMENT

Professor Whipple continued his work in the area of evaluation and analysis of the structure of the DOD Productivity Enhancement Program. Professors Boger and Whipple continued their investigation of the potential relationship between U.S. coal reserves and a "market-based" defense strategy. D. Boger continued and effort to determine the composition of overhead costs in major aerospace defense contractors. P. Bromiley continued his study of the determinants of corporate capital investment. Professors Boger and Bromiley began an investigation into the predictive performance of alternative models of corporate capital investment. W. Greer conducted research on using accounting information to predict a contractor's pricing strategy. Professors Greer and S. Liao continued their research on the economic consequences of sole source versus dual source procurement of advanced major weapon systems. Professor Liao also studied the internal auditing practices in governmental units. F. Horton continued his work on comparing the cost effectiveness of conventional versus computer-involved instructional techniques. Professor Perret continued her examination of the nature of adaptation of budgeting systems to different environments. P. Carrick conducted a study to evaluate the costs and benefits of competitive contractor teaming as an acquisition strategy. Professor Carrick joined C. Peterson in conducting a study of validity of questionnaire data with respect to intertemporal choice. Professor San Miguel continued his research on the use of alternative financial reporting policies by the largest U.S. companies. K. Euske continued his work on analysis of methods for use in the accrual of manpower costs. He also continued his developed work on a communication system for Marine Corps unit commanders. Professors Euske and Ansari began a project to study cost accounting systems within military maintenance facilities. Professor Ansari initiated a study to test and model the behavior of reactive control systems.

#### MANPOWER, PERSONNEL, AND TRAINING RESEARCH

M. Eitelberg and R. Elster, along with D. Zimmerman, began a major project on applying a quantitative approach to the development of improved selection and classification standards for the military services. Professor Eitelberg also examined the relationship between enlistment standards and youth participation in the military as part of

an ongoing major research effort, including a policy analysis of aptitude and education standards and a comprehensive study of racial/ethnic minorities in the military. J. Goral began a systems analysis of the Defense Personnel Security Program to improve the use of psychological selection and monitoring techniques for sensitive positions. Professor Nieboer continued an evaluation of the use of commercially-available aptitude tests to supplement the Defense Student Testing Program, and began a related effort to study the efforts of offering an interest measure in the program. Professor McGarvey continued his longitudinal study of ship manpower readiness. Professor Thomas continued his interest in the secondary recruiting market by beginning a project to develop a study plan for the Army for assessing and targeting the market for older-age enlistees. He also initiated a project to develop an Army Reserve supply/unit location model. Professor Thomas began research on a unit capability model and continued his research on the organizational commitment of military juniors. T. Sticht and L. Armijo began work on a literacy and comprehensive training curriculum which focuses on improving the ability of participating Navy enlisted personnel to read, comprehend, and effectively utilize Navy written materials. R. Weitzman continued his research on the application of sequential aptitude testing for recruit selection and assignment, brought in the Rasch model to facilitate the estimation required and performed additional research on the Rasch model in relation to multiple-choice testing. Professor T. Swenson began a project to study applications of "spreadsheet" software to manpower modeling. Professor B. Bloxom worked to develop practical methods for analyzing and comparing human performance time distributions.

#### ORGANIZATIONAL SCIENCES

C. Eoyang, R. Harris, R. McGonigal, E. Hamilton, and R. Dreher continued their long term research program in organizational development (OD). Their extensive field work continued to make significant contributions to the Navy's program in Human Resource Management/Organizational Effectiveness. Professor Harris initiated a series of studies on "excellence" in operational military organizations. C. Eoyang began a project entitled, "Bureaucratic Design: Organizing the Navy", which examines the relationships between organizational effectiveness and organizational form. Professor Hamilton began a study of Navy organizational consultants which examines the relationship between consultant effectiveness, personality factors, and consultant knowledge of OD theory and technology. R. Evered continued his research in both the Strategic Management area and the epistemology of social science research. D. Whipple continued his investigation into the

existence of an interdisciplinary predictive theory of intra-firm behavior. J. LaPatra initiated a feasibility study of the Nationwide Emergency Telecommunications System (NETS).

Title: An Empirical Investigation of the Behavior of  
Reactive Control Systems

Investigator: S. L. Ansari, Adjunct Professor, Department of  
Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: To empirically test and model the behavior probability distribution) of free flowing speeds on U. S. highways in response to the imposition of the 55 mph speed limit in 1974. Traffic speeds were used as prototypes for so-called reactive control systems in which the control policy itself (as opposed to negative feedback) causes behavioral changes in the system.

Summary: The project was funded in January 1984. Since then 80% of the work has been completed. This includes an extensive amount of data collection from the states of New York, Nevada, California and Texas. Preliminary analysis of this data is also complete and some results are currently available. A final model is presently being refined and tested to complete the project.

Conference  
Presentation: S. L. Ansari, "Modeling Human Behavior in Reactive Control Situations," TIMS Annual Meeting, Copenhagen, Denmark, June 1984.

Title: A Productivity Enhancement Study of the FMSO Information Processing Facilities

Investigators: D. C. Boger, Assistant Professor  
N. R. Lyons, Associate Professor

Sponsor: Fleet Material Support Office

Objective: Survey the productivity enhancement techniques in use at FMSO, compare these with measures in use in industry, and develop a productivity enhancement implementation strategy.

Summary: This is an on-going project, hopefully the first in a series of studies for FMSO. In the initial study, we identified areas in the software development work at FMSO that are candidates for productivity improvement. We gave a preliminary report on this effort in January 1983 in a two-hour presentation at FMSO. Copies of the report were left for detailed comment and correction. The copies came back in the summer, and a final report is being prepared (somewhat delayed by my hospitalization this summer).  
  
The research effort is continuing in slightly different directions than the original charter. The command wanted to do work with office automation concepts. To this end, we offered to develop a prototype office automation system for handling one of their areas of concern--the reporting of Quality Deficiency problems in supplies received (QDR reports). We acquired four IBM PC's, a variety of I/O equipment and Orchid PC-NET and set up two systems, one at NPS and a duplicate system at FMSO. The prototype system is well underway and should be ready for presentation in the Fall of 1983. The idea behind this effort is to try to establish an "NPS connection" to provide continuing contact with FMSO so that NPS thesis students can work on problems of concern to the command in their theses.

Conference Presentation: D. C. Boger, C. R. Jones and N. R. Lyons, "Social Equity in Computer Management: The Federal Government Dilemma," TIMS/ORSA Conference, San Francisco, California, 15 May 1984.

Publications: D. C. Boger, C. R. Jones and N. R. Lyons, "Improving Information Systems Management: Technological

Opportunities and Social Constraints," Proceedings of the Fourth International Conference on Information Systems, Society for Information Management, 111 East Wacker Drive, Suite 600, Chicago, Illinois 60601, Houston, Texas, 15-17 December 1983, pp. 163-174.

D. C. Boger and N. R. Lyons, "The Organization of the Software Quality Assurance Process," Database--forthcoming in 1985.

Theses Directed:

J. Boynton and R. Nichols, "The Implementation of a Central Database on a Network of Microcomputers," Master's Thesis, March 1984.

J. M. DeLorenzo and S. Larue, "A Comparative Analysis of DOD Computer Systems Acquisition Costs to the Private Sector," Master's Thesis, March 1984.

Title: An Automated Attitudinal Management System

Investigators: J. I. Borack, Adjunct Professor of Administrative Sciences and E. P. Somer, Navy Personnel R&D Center

Sponsor: Chief of Naval Operations

Objective: To develop a methodology for dynamically retrieving attitudinal data in a quick, response framework. To develop a framework for comparing computerized, paper and pencil, and telephone data gathering techniques.

Summary: A test-bed was developed for assessing the feasibility of collecting attitudinal data via terminal. A two-stage sampling scheme was used to select activities and then individuals within activity in the San Diego area. Data collection will commence during FY85.

Title: Retention Planning Models

Investigators: J. I. Borack, Adjunct Professor of Administrative Sciences; R. H. Mumm, Navy Personnel R&D Center

Sponsor: Office of Naval Technology

Objective: To develop a methodology for creating thirty-year survival (retention) estimates from a limited subset of data.

Summary: An intensive study of biostatistical methodologies was undertaken. A pooled, cross-sectional life-table methodology was employed to create long-term survival curves. The technique proves very useful in comparing different subpopulations and in establishing trends across time.

Publication: R. H. Mumm, J. I. Borack, K. A. Murphy, "The Graphical Analysis of Survival Probabilities (GASP) Methodology and Users Guide," Navy Personnel Research and Development Center, TR 85 (in final review), 1984.

Presentation: R. H. Mumm, "Retention Planning Models," Joint Marketing and Advertising Research Committee, San Diego, California, December 1983.

Title: Alternative Manpower Supply Methodologies

Investigator: J. I. Borack, Adjunct Professor of Administrative Sciences

Sponsor: Navy Personnel R&D Center

Objective: Develop a prospectus for integrating diverse manpower supply methodologies into a logical framework.

Summary: A thorough examination of existing demographic, econometric, and survey approaches relating to manpower supply was undertaken. The strengths and weaknesses of each methodology were catalogued and it was found that no single technique was satisfactory. These three methodologies were integrated into a logical framework which represented supply as a dynamic process rather than a single model.

Publication: J. I. Borack, A Framework for Integrating Alternative Supply Methods, Navy Personnel and Development Center Technical Report, TR 84-42.

Presentation: J. I. Borack, "Alternative Supply Methodologies," International Meeting of the Institutes of Management Science, Copenhagen, Denmark, June 16, 1984.

Title: Alternative Models of Corporate Capital Investment and Their Implications for DoD Procurement

Investigators: P. Bromiley, Assistant Professor  
D. C. Boger, Assistant Professor  
Department of Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: To compare six alternative models of corporate capital investment based on their predictive capabilities.

Summary: In response to concerns with the productivity and surge capacity of the defense industrial base, the Department of Defense has implemented a number of programs to improve the production facilities and profitability of defense contractors. Unfortunately, these programs have been undertaken without a thorough knowledge of the capital investment behavior of defense contractors. However, this is not surprising since several alternative models of investment behavior exist, and the models have not been well compared empirically. This research compared alternative models of investment based on how well they predict. The sample of firms included both defense-oriented and non-defense-oriented firms. It was shown that simpler models were able to predict at least as well as more complex models.

Publications: A technical report is in preparation, and a paper is being submitted to the open literature.

Title: The Use of Competition in the Airborne Self-Protection Jammer (ASPJ) Acquisition Program

Investigator: Paul M. Carrick, Associate Professor of Management  
Department of Administrative Sciences

Sponsor: Naval Air Systems Command

Objective: To evaluate the costs and benefits of competitive contractor teaming as an acquisition strategy. This should be viewed as one step in the evaluation of not only the use of competition but also the formulation and scheduling of an effective acquisition strategy.

Summary: Competitive contractor teaming (CCT) was found to be an efficient acquisition strategy for inducing contractors to subsidize a development program. It was not possible to determine how the competition was conducted in a verifiable manner since the pertinent project managers were no longer associated with the project. It was determined that the savings to the government from using competition early in an acquisition effort might be more apparent than real.

Publications: P. M. Carrick, "Evaluation of the Competitive Contractor Teaming Strategy on the ASPJ Program," (paper submitted to research sponsor and interested parties).  
P. M. Carrick, "Evaluation of the Competitive Contractor Teaming Acquisition Strategy," National Contract Management Association Journal, to appear December 1984.

Title: Determination of Personal Discount Rates

Investigators: Paul M. Carrick, Associate Professor of Management  
Clair A. Peterson, Associate Professor of Economics  
Department of Administrative Sciences

Sponsor: Chief of Naval Operations

Objective: Develop a questionnaire by which to determine individuals' personal discount rates used in their intertemporal resource allocation decisions.

Summary: It was determined that it was premature to develop a questionnaire for ascertaining individual's personal discount rates. It became apparent that much previous work on this topic was based upon faulty premises and inadequate statistical methods. An attempt was made to determine the structure of the decision process by which individuals arrive at an intertemporal resource allocation. The Life Cycle Income-Consumption model was thoroughly investigated. It was also determined that individuals' response to uncertainty were also an important factor affecting their intertemporal allocation choices. Consequently, the risky decision-making literature was also reviewed. A provisional synthesis of these two disparate conceptual approaches to choice assessment was outlined.

Publications: P. M. Carrick, "Determining the Price of Future Consumption," (paper prepared and submitted to the research sponsor), 57 pages.  
P. M. Carrick, "Determining the Discount Rate for Government Investment Projects," (in preparation).

Title: NAVSTAR GPS Program Phase III Acquisition Plan, R&D Management and Production Procurement Options Support

Investigator: W. H. Cullin, Adjunct Research Professor, Department of Administrative Sciences

Sponsor: Naval Electronics Systems Command

Objective: To provide analysis and evaluation of management options for Phase III milestone decision documentation/plans/acquisition strategies.

Summary: Management Planning documentation, i.e. Acquisition Strategy, Source Selection Plan, Acquisition Plan, SOW, have been reviewed, evaluated and input provided. Attendance at scheduled meetings of the GPS Phase III Planning Group have been the forum for inputs to the management of the GPS in support of the U.S. Navy Deputy Program Manager of the Joint program office at the Space Division, Los Angeles Airforce Station, Los Angeles, California.

Theses Directed:

W. Schull and R. Nanney, "Analysis of the NAVSTAR-GPS AVSTALL User Equipment Installation Cost Model," Master's Thesis, December 1983.

K. Amos, "Installation Options for NAVSTAR-GPS in Surface Ships," Master's Thesis, June 1984.

S. Burns and D. Atkins, "Analysis of MILSTAR Terminal Life Cycle Cost Model," Master's Thesis, December 1984.

A Fourman, "Installation Considerations for NAVSTAR-GPS in Support Ships," Master's Thesis, December 1984.

Title: A Data Dictionary Design for the Force Manpower Operations Center Decision Support System

Investigator: D. R. Dolk, Assistant Professor of Administrative Sciences

Sponsor: U. S. Army Military Personnel Center

Objective: Determine the requirements for, and preliminary design of, a data dictionary/directory system (DD/DS) for the Force Manpower Operations Center decision support system (DSS). The function of the DD/DS is to control the data resources required by the DSS in its operation as well as provide an environment for integrating the various models which underlie the system. The analysis and design is the first step in building a DD/DS which will eventually be incorporated into the FMOC DSS.

Summary: This project is intended as the first step in an ongoing research effort which hopefully will continue into future periods. The effort during this year was devoted primarily to identification of the data and modeling resources which MILPERCEN considers significant in their operations. This information will be incorporated into an initial version of a dictionary system using dEASE II database management system software. This dictionary will evolve according to user needs perceived from use of the prototype and ensuing versions.

Theses Directed:

R. Broome, "An Analysis of Information Resource Management Within the Deputy Chief of Staff for Plans, U. S. Army Military Personnel Center," Master's Thesis, March 1985.

R. DiBona, "The Role of a Data Dictionary in Enforcing Data Integrity," Master's Thesis, March 1985.

A. Noel, "The Role of a Dictionary System in Prototyping," Master's Thesis, March 1985.

Title: A Distributed Dictionary/Directory System for the ORACLE DBMS

Investigator: D. R. Dolk, Assistant Professor of Administrative Sciences

Sponsor: Naval Ocean Systems Center

Objective: Investigate the current dictionary capabilities of the ORACLE relational database management system and determine the feasibility of interfacing ORACLE with an existing commercial dictionary system. These are preliminary steps which must be achieved in order to arrive at an eventual design for a distributed dictionary/directory system.

Summary: The results of this study revealed that ORACLE has a very limited dictionary/directory capability which must be significantly enhanced to function within a distributed computing environment. Two approaches are recommended for this enhancement:

1. develop a relational model of a dictionary/directory system within ORACLE itself, and
2. investigate interfacing ORACLE with an existing commercial dictionary system such as DataManager.

It is anticipated that further funds will become available in FY85 to consider further both of these approaches.

Theses Directed: S. Landin, "An Analysis of Data Dictionaries and Their Role in Information Resource Management," Master's Thesis, September 1984.

R. Owens, "An Analysis of Data Dictionaries and Their Role in Information Resource Management," Master's Thesis, September 1984.

D. L. Robertson, "Data Dictionary Systems and Their Role in Information Resource Management," Master's Thesis, March 1984.

Title: Model Patternmatching in Model Management Systems

Investigator: D. R. Dolk, Assistant Professor of Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: Study the structural characteristics of classes of models with regard to how they may be matched to potential solution algorithms. Determine a methodology for this and develop algorithms which implement this methodology.

Summary: This project is a continuation of research funded by the Foundation in the previous fiscal year.

Title: Army Recruiting Studies: Tasks I-III

Investigators: M. J. Eitelberg, Adjunct Professor  
D. Zimmerman, Adjunct Research Instructor  
R. Zimmerman, Adjunct Professor  
Department of Administrative Sciences

Sponsor: U. S. Army Recruiting Command

Objective: To perform three research tasks. Task I is a study of personnel attrition in the Army's Delayed Entry Program (DEP). Task II seeks to develop and validate an Enlistment Suitability Index (ESI) for use in personnel screening and selection in the Army. Task III examines the feasibility of recruiting college-bound youths through use of the ACT Assessment File.

Summary: This is an ongoing project that commenced in late fiscal 1984. Preliminary work has been accomplished on each of the three research tasks. The project completion date is July-August 1985.

Publications: Separate final reports will describe the results of the three research tasks.

Title: Analyses in Support of the Defense Manpower Data Center

Investigators: M. J. Eitelberg, Adjunct Professor  
J. Goral, Adjunct Professor  
Department of Administrative Sciences

Sponsor: Defense Manpower Data Center

Objective: To create and analyze several data files and merged data files on enlisted accessions and active duty military personnel.

Summary: This is an ongoing research project. Project personnel have designed special data files and conducted several manpower studies and analyses on a DOD-wide basis. Task areas during the current period have included the following: enlisted selection and classification standards, the Defense Personnel Security Program, systems development of the Defense Enrollment Eligibility Reporting System (DEERS), indices of personnel quality and DOD accession policy, ship manpower readiness, Delayed Entry Program (DEP) attrition, and other Defense manpower programs.

Publications: The products of the research project were new DOD manpower data files, merged data files, and statistical reports of data on the files.

Title: Enlistment Standards and Youth Participation in the All-Volunteer Force

Investigator: M. J. Eitelberg, Adjunct Professor, Department of Administrative Sciences

Sponsor: Directorate for Accession Policy, Office of the Assistant Secretary of Defense (Manpower, Installations and Logistics)

Objective: To perform six integrated research tasks in the subject areas of enlistment standards and youth participation in the All-Volunteer Force. Among the major tasks are the following: A policy analysis of educational credentials used to determine enlistment eligibility; a study of Hispanics and the military; a demographic evaluation of the QMA population (18-23 years old) by military occupation.

Summary: This is an ongoing research project (and a summary was included in last year's report).

During the current reporting period, research focused on the study of Hispanics and the military, the analysis of educational credentials, and the QMA study (by military occupation).

- The project investigator has completed compiling sources (over 300 major references) and preparing statistical tables for the study of Hispanics and the military. Draft chapters have been completed for a book on Hispanics and the military. An annotated bibliography has also been prepared for separate publication.
- A data base was constructed for analyzing educational credentials used by all four services. A report was prepared that examined the first-term performance of persons with different types of educational credentials, recommending certain improvements in the way the military services treat nontraditional credentials for enlistment screening.
- Standards (aptitude and education) used by Army, Navy, Marine Corps, and Air Force for assigning new recruits to occupational training were assembled. Assignment models for all four services were then developed and combined with

data from the "Profile of American Youth" to derive estimates of the percentage and number of young men and women (nationwide, by racial/ethnic group, age, geographic area, and education) who would qualify for training in each occupation in the separate services. (The results are now being placed in a form suitable for publication.)

Publications: Three publications are currently in progress, including a commercial-length book on "Hispanics and the Military."

Theses Directed: D. B. Franke, "Evaluation of Marine Corps Educational Credentials," Master's Thesis, December 1983.

T. V. Johnson, "A Description of Profile of American Youth Data for Military Manpower Personnel Analysis," Master's Thesis, December 1983.

D. Daniels, "Minority Participation in Navy Jobs," Master's Thesis, December 1984 (in progress).

S. Deuterman, "Expanded Use of Women in the Navy: A Case Study," Master's Thesis, December 1984 (in progress).

Title: Development of an Enlistment Suitability Index for Navy Enlisted Personnel

Investigators: M. J. Eitelberg, Adjunct Professor  
D. C. Zimmerman, Adjunct Research Instructor  
E. S. Flyer, Consultant, Manpower Research Center  
Department of Administrative Sciences

Sponsor: Navy Personnel Research and Development Center

Objective: Development and validation of a composite of pre-enlistment variable scores predictive of first-term attrition of Navy enlisted personnel.

Summary: Extensive cross-tabular analyses were used to determine interactive effects of variables such as age at service entry, AFQT category, educational level, and amount of time spent in the Delayed Entry Program and other variables known to affect early discharge. Individuals were assigned an attrition probability score based on the actual attrition experienced by groups of individuals representing unique combinations of entry factors (e.g. age, mental category and educational level). The composite scores were validated on a later accession cohort group, and compared with current screening scores. The screening composites developed in this study appeared to be more efficient in terms of percent of total applicants eliminated versus percent elimination of failures (those who fail to complete a first tour), than the currently employed screening device.

Publication: E. S. Flyer and D. C. Zimmerman, "Development and Validation of Composites Predictive of Attrition for Navy Male Accessions," BDM/M-TR-0048-84, September 1984.

Title: Study of Ship Manpower Readiness

Investigators: M. J. Eitelberg, Adjunct Professor  
D. Zimmerman, Adjunct Research Instructor

Sponsor: Chief of Naval Operations

Objective: To produce computer-based statistical reports that examine the relationship between material readiness and various ship-manning conditions. (This is the second phase of a continuing project. Previous research developed a data base on ship manpower readiness, and exploratory analyses were conducted.)

Summary: Previous research (phase 1) indicated that the relationship between improved manning conditions and measurable increases in material readiness is not consistent across all enlisted rating groups. In reviewing the initial research, it was determined that many independent variables such as ship deployment status, time spent in or out of overhaul, and other factors were partially influencing material readiness. It was also determined that a greater degree of detail (paygrade and NEC) in the manpower side was needed to fully investigate the relationship between material readiness and ship manning conditions. Research on this project has started to produce computer-based statistical reports examining the relationship of material readiness to various ship manning conditions (with material readiness reflected in the amount of major equipment downtime as shown in CASREPTS and UNITREPS). The research will also attempt to develop a macro-level model of the cost relationship between expenditures to improve manning and savings from increased fleet operational capability.

Publications: This project will result in various reports, including a technical monograph.

Title: Evaluation of Reenlistment Eligibility as a Job-Related Performance Criterion for Setting ASVAB Entry Standard

Investigators: M. J. Eitelberg, Adjunct Professor  
D. C. Zimmerman, Adjunct Research Instructor  
E. S. Flyer, Consultant, Manpower Research  
Department of Administrative Sciences

Sponsor: Chief of Naval Operations

Objective: Validation of the ASVAB with reenlistment eligibility as a measure of performance. Paygrade at time of separation by reenlistment eligibility and rating by reenlistment eligibility also of interest need to be compared with attrition/non-attrition status (a traditional performance criterion).

Summary: Reenlistment eligibility rates show reasonable stability over time. However, an exam policy change in FY79 resulted in more individuals becoming eligible for reenlistment. The relationships are high between reenlistment eligibility, attrition and paygrade attainment. Reenlistment eligibility accounts for supervisory evaluations and proficiency scores as well as attrition/non-attrition status. Some of the relationships between reenlistment eligibility and ASVAB subtest scores are as strong as some enlistment (entry) factors such as age and AFQT category.

Publication: E. S. Flyer, "Evaluation of Reenlistment as a Navy Performance Criterion," Human Resources Research Organization, September 1984.

Title: An Analysis of Methods for Use in the Accrual of Manpower Costs

Investigator: K. J. Euske, Associate Professor, Department of Administrative Sciences

Sponsor: Director, Manpower Planning and Analysis, Office of the Assistant Secretary of Defense

Objective: The objective of this project is to analyze the full cost to the taxpayer of a manpower decision.

Summary: The analysis includes questions of the proper accrual method and may include questions of allocation, depending on the types of resources affected by the decision.

Publication: K. J. Euske, D. Smith, and G. W. Thomas, "Accounting for and Reporting Military Retirement Costs to Manpower Decision Makers," in Proceedings of the Western American Institute for Decision Sciences, Honolulu, March 15-16, 1984. (Revised version of paper submitted to Decision Sciences.)

Theses Directed: D. F. Smith, Jr., "A Sensitivity Analysis of Entry Age Normal Military Retirement Costs," Master's Thesis, September 1983.  
S. Waterman, "Allocation Methods for Use in the Accrual of Manpower Costs," Master's Thesis, June 1983.

Title: Development of a Back-Channel MCCRES Reporting System

Investigator: K. J. Euske, Associate Professor, Department of Administrative Sciences

Sponsor: Headquarters United States Marine Corps

Objective: To develop a communication system that provides positive, meaningful information to the unit commander.

Summary: Measuring the readiness of a military unit through the use of MCCRES data base, provides a vehicle to supply the unit commander with information that will assist him in using limited resources effectively and efficiently to accomplish the unit's objectives. The information should both be meaningful and provide positive input to the unit commander. The information must be tailored such that the unit commander can actively use the input to alleviate actual or perceived relative deficiencies.

Publications: K. J. Euske, T. P. Finnerty and J. F. Mullane, "Feedback Systems for the Marine Corps Combat Readiness Evaluation System," NPS-54-84-018, February 1984.  
K. J. Euske, G. M. Wheeler and J. F. Mullane, "An Analysis of Evaluator Bias in the Marine Corps Combat Readiness Evaluation System," NPS Technical Report. Under review by sponsor.

Theses Directed: L. E. Conatser, "Marine Corps Combat Readiness Evaluation System (MCCRES): Three Case Studies for Use in Providing a More Effective Evaluator," Master's Thesis, December 1983.  
T. P. Finnerty, "An Analysis of the Feedback From the Marine Corps Combat Readiness Evaluation System," Master's Thesis, December 1983.  
G. M. Wheeler, "Evaluator Bias in the Marine Corps Combat Readiness Evaluation System (MCCRES): Its Identification and Control," Master's Thesis, June 1983.

Title: Depot Maintenance Cost and Production Accounting and Reporting

Investigators: K. J. Euske, Associate Professor of Accounting, Department of Administrative Sciences; S. L. Ansari, Adjunct Professor of Accounting, Department of Administrative Sciences

Sponsor: Director, Logistics and Material Management, Office of the Assistant Secretary of Defense

Objective: The purpose of this project is to document, evaluate and validate the cost accounting systems used by depots.

Summary: Of particular interest is the compilation of cost information for reporting to OASD. The study will attempt to determine if the depot cost system provides information which is consistent with the requirements of OASD SD or whether the two cost information systems are "disconnected". If such disconnections are present, the study will attempt to determine the sources and causes for such disconnections. The study is designed to both thesis students and the co-investigators in use the research process.

Theses Directed:

J. L. Burnett, "Documentation and Evaluation of Depot Maintenance Cost Accumulation and Reporting at the Naval Air Rework Facility, Jacksonville, Florida," Master's Thesis, June 1984.

F. D. Gorris, "Documentation and Evaluation of Depot Level Maintenance Cost Accumulation and Reporting at the Air Force Logistics Command, Sacramento, California," Master's Thesis, June 1984.

K. J. Tackett, "Documentation and Evaluation of Depot Maintenance Cost Accumulation and Reporting at the Sacramento Army Depot, Sacramento, California," Master's Thesis, June 1984.

Seven additional theses in progress.

Title: Personnel Security Research Program

Investigator: J. R. Goral, Adjunct Research Professor of Psychology  
Department of Administrative Sciences

Sponsor: Office of the Deputy Under Secretary of Defense

Objective: To develop an ongoing series of systems analyses of the DOD Personnel Security Program, focusing on the prescreening of applicants for sensitive positions, background investigation techniques, adjudication of clearance actions, and the interconnection of DOD security and personnel data bases. The long-range goals of the project are to provide the sponsor with program evaluation capability and to improve personnel security in the Department of Defense.

Summary: Detailed computer studies were made of the investigative and clearance contents of the 15 million record Defense Central Index of Investigations. Linkages were accomplished with current DOD personnel inventories and a ten year enlistee cohort file. Problem areas were identified by these studies including a large number of duplicate entries in the security data base, high unsuitability attrition among cleared personnel, and inadequate coordination between the personnel and security communities resulting in the failure to modify the clearance status of personnel discharged for cause.

Modeling of alternate periodic reinvestigation workload requirements was accomplished and various management information analyses were provided to the sponsor. Also, preliminary observations were made of both the pre-screening and subject interview phases of the personnel security process. Hard copy pre-screening test results were obtained from the Army, Navy, and Air Force and have been coded for use in validation and reliability studies currently underway.

Publications: J. R. Goral, "Personnel Security Investigation and Clearance Contents of the DCII," Personnel Security Research Program Technical Report, 84-1, March 1984.

J. R. Goral, "DIS Investigations and Army and Air Force Adjudications Contained in the DCII," Personnel Security Research Program Technical Report, 84-2, May 1984.

J. R. Goral, "Army and Air Force Adjudications During FY83 and DIS Investigation and Clearance Status of DOD Personnel as of the End of FY83," Personnel Security Research Program Technical Report, 84-3, June 1984.

J. R. Goral, "Investigation and Clearance Status of Those in Army Personnel Security Screening Program Occupations," Personnel Security Research Program Technical Report, 84-4, July 1984.

J. R. Goral, "Identification of Army Top Secret Eligibles Not Included in DCII Clearances," Personnel Security Research Program Technical Report, 84-5 July 1984.

J. R. Goral, "Navy Security Clearances," Personnel Security Research Program Technical Report, 84-6, August 1984.

J. R. Goral, "Projections of Military Periodic Review Requirements," Personnel Security Research Program Technical Report, 84-7, August 1984.

J. R. Goral, "Security Clearances Among Army and Air Force Reserve Component Personnel," Personnel Security Research Program Technical Report, 84-8, September 1984.

J. R. Goral, "Comparison of Investigations and Adjudications During FY83 and the First Half of FY84," Personnel Security Research Program Technical Report, 84-9, September 1984.

Title: Cost Analysis for Competitive Major Weapon Systems  
Procurement: Further Refinement and Extensions

Investigators: W. R. Greer, Jr., Professor  
S. S. Liao, Professor  
P. M. Carrick, Associate Professor  
Department of Administrative Sciences

Sponsor: Office of Naval Research

Objectives: This study is an extension of our earlier work. The objective is to expand the data base and develop a reliable method for forecasting production capacity utilization (CU) so that a model for quantifying savings from competition can be refined and implemented by the Navy. The contractor team approach as a competitive procurement tool will be examined.

Summary: We examine the desirability of using firm-specific measures of business conditions to predict defense contractors' pricing behavior. The result shows that the aerospace industry (CU) is more reliable than other measures of business conditions. Attempt to develop a reliable model for projecting aerospace industry's CU resulted in a dynamic model which expresses the change in capacity as a function of present and recent past state of CU and the expected change in output. Output is found to be highly correlated with Five Year Defense Plan. Further analysis of historical data shows that the cost savings which result from dual sourcing are a function of CU and the division of the procurement between the original supplier and the second source. On the other hand, when procurements are conducted under sole sourcing, the direction of the impact of CU changes on prices is just the opposite. Several additional programs were identified as suitable for inclusion in studies of dual source competition. A quick validation check confirms the strength of our model.

Publications: W. R. Greer, Jr. and S. S. Liao, "Cost Analysis for Competitive Major Weapon Systems Procurement: Further Refinement and Extensions," Naval Postgraduate School Technical Report, NPS54-84-23, September 1984.  
Working paper preparation in progress.

Presentation: S. S. Liao and W. R. Greer, Jr., "Cost Analysis for Competitive Major Weapon Systems Procurement: Further Refinement and Extensions," OSD, Defense Acquisition Research Element, Fort Belvoir, Virginia, 30 July 1984.

Thesis Directed: D. E. Franklin, "Determination of Substitutes for Capacity Utilization Rates for Individual Companies in the Aerospace Industry," Master's Thesis, March 1984.

Title: Influence Behavior and Effectiveness in Naval Decision-Making Groups

Investigator: E. E. Hamilton, Adjunct Professor of Administrative Sciences

Sponsor: None

Objective: To test whether both agentic (self-assertion, self-expansion, self-protection) and communal (selflessness) behavior are related and influence effectiveness in Naval decision-making groups.

Summary: The results were highly significant in the direction of the hypothesis. Individuals high in both agency and communion were more effective than those low in agency or low in communion.

Publications: Papers are now being written for journal submission.

Title: Human Resource Management System: Research and Support Project

Investigators: R. T. Harris, Associate Professor of Management  
C. K. Eoyang, Associate Professor of Management  
Department of Administrative Sciences

Associate Investigators: R. McGonigal, Associate Professor of Management  
CDR R. Bishop, Instructor in Management  
E. Hamilton, Adjunct Professor  
R. Dreher, Adjunct Professor  
Department of Administrative Sciences

Sponsors: Chief of Naval Operations  
Naval Military Personnel Command

Objective: To provide continuing research, analysis, training and consultation support to the U. S. Navy's Human Resource Management Support System (HRMSS) at both field and staff levels.

Summary: Since FY79, numerous activities were conducted under this project in support of the above objective. Two long-term demonstration projects were undertaken with the goal of improving the capability of HRMC's and documenting the strategy and outcomes of those efforts. The two project sites are HRMC San Diego and HRMC Pearl Harbor. Also NPS faculty have delivered training activities at HRMC's and HRMD's at Pearl Harbor, San Diego, Alameda, Norfolk, Charleston, Washington, DC, Whidbey Island, and NPS. NPS faculty planned and managed the Military HRM Symposium held at NPS (November 1978). NPS faculty designed and delivered annually since 1979 a two-week Advance OD course for Navy OD specialists.  
  
Regarding activities of the past year, the major thrust has been in two areas. Significant resources were employed in delivering advanced conceptual and skill training in OD to consultants in the Navy's HRMSS. These included a two-week course (60 participants) at NPS and on-site training in Europe and throughout CONUS. Secondly, faculty have provided the sponsor with personal consultations regarding OP-15/NMPC-6 efforts directed at reorganization of the Navy's HRMSS. Also, consultation services have been provided to NAVMEDCOM and the Navy Surgeon General concerning reorganization of the Navy Bureau

of Medicine and Surgery (BUMED). Included in this area are several theses focused on topics relevant to the sponsor's current interests and priorities. Finally, NPS faculty have been integrally involved with implementation and strategic planning efforts at OEC San Diego, OEC Norfolk, and OESYSPAC.

Of particular significance, during the past year in Washington, Professor Eoyang has been intimately involved in the planning to redirect and restructure the Navy's organizational effectiveness program. As special assistant to OP-15, he served as the principal management advisor for organizational matters and consulted on a broad range of program issues, including reorganization of Headquarters staff, formulation of Naval policy, and strategic planning for the OE system.

Theses Directed:

R. J. Burch, "The Navy's Consultant Development and Qualification Program," Master's Thesis, March 1984.

G. G. Gullickson and R. D. Chenette, "Excellence in the Surface Navy," Master's Thesis, June 1984.

M. Pierce and R. Porter, "Excellence at Sea in the USCG," Master's Thesis, December 1984.

J. Simonsen, D. Hoopengardner and H. Frandson, "In Search of Excellent Army Combat Arms Battalion," Master's Thesis, December 1984.

J. McInerney and W. Hackett, "Identify Personality Characteristics of Excellent Organizational Effectiveness Consultants in the U.S. Navy," Master's Thesis, December 1984.

H. Forde, "Accelerated Learning at NPS: A Study of the Feasibility of Using Accelerated Learning Methodology in the Initial Instruction of Quantitative Fundamentals," Master's Thesis, March 1985.

J. Norton, "Excellence in Medical Care," Master's Thesis, December 1984.

S. Sigler, In Search of Excellence in VP Squadron," Master's Thesis, December 1984.

Title: Manpower Budget Estimates for the 600-Ship Navy

Investigators: D. R. Henderson, Adjunct Professor, Department of Administrative Sciences; and D. R. Whipple, Jr., Professor, Department of Administrative Sciences

Sponsor: Chief of Naval Operations

Objective: To prepare budget estimates for the cost of manpower required to man a 600-ship Navy.

Summary: The particular piece of the project I worked on is a comparison of uniform versus targeted enlistment bonuses to achieve level-loading in the Nuclear Field. "Level-loading" means having approximately equal numbers of recruits enter the Nuclear Field throughout the year. The Navy wants level-loading to avoid making recruits wait for training. During FY84, I proved that targeted bonuses are cheaper than uniform bonuses, and did some preliminary estimates of the cost saving from a targeted bonus system.

Title: Analytic Capability in Support of the National Communications System

Investigators: J. LaPatra, Adjunct Professor of Systems Analysis  
Department of Administrative Sciences  
C. R. Jones, Professor of Information and Telecommunications Systems, Department of Administrative Sciences  
J. Yee, Adjunct Professor of Operations Research  
J. Wozencraft, Professor of Electrical Engineering

Sponsor: National Communications System

Objective: To provide recommendations regarding the development, acquisition, operation of the Nationwide Emergency Telecommunications Network (NETS).

Summary: The development, acquisition and operation of the NETS can be analyzed in terms of the supply of services and the demand for those services. The supply of services involves the development and implementation of routing and flow procedures that will maximize connectivity in a post attack environment. Since the surviving assets of the nation-wide telecommunications system are uncertain, the procedures must be robust and the prior attack location of post attack system reconstitution equipment prior to attack must be carefully chosen. The demand for services can be studied based on the mission and planned organization structure and processes post attack. This will involve indepth interviews in addition to analysis of planning documents. Work to date has involved the development of a method to obtain measures of demand, routing and flow procedures and the proper sizing of NETS.

Thesis Directed: K. A. Williams and E. C. Partridge, III, "Logical Design of a Decision Support System to Forecast Technology, Prices and Costs for the National Communications System," Master's Thesis, September 1984.

Title: Acquisition Strategy

Investigators: D. V. Lamm, Assistant Professor of Administrative Sciences  
R. L. Schill, Adjunct Professor of Administrative Sciences

Sponsors: Naval Sea Systems Command and Navy Office of Acquisition Research

Objective: To develop a methodology for analyzing NAVSEA acquisition strategies and for determining ability to achieve competition during the Production/Deployment phase of major weapon systems acquisition process.

Summary: A survey of current acquisition strategies in use by all DOD services was performed to determine the structure and thrust of such strategies. A review of the acquisition literature was begun to determine policy, guidance, practices and procedures in developing and implementing an acquisition strategy. Interviews were held with Navy and Air Force policy officials regarding acquisition strategy requirements and DOD project managers concerning strategy implementation problems. This is the first phase of the acquisition strategy research project.

Conference Presentations: D. V. Lamm and D. Wilcox, "Implementation of Acquisition Strategy," DARE Acquisition Strategy Workshop, Fort Belvoir, VA, 1-2 May 1984.  
D. V. Lamm, "Acquisition Strategy," 2nd Annual SOLE Symposium on Logistics Research and Applications, Naval Postgraduate School, Monterey, CA, 19 May 1984.

Thesis Directed: B. Bissett, "Acquisition Strategy at Program Initiation," Master's Thesis, December 1984.

Title: Analytic Capability in Support of National Communications System

Investigators: J. LaPatra, Adjunct Professor  
C. Jones, Professor  
Department of Administrative Sciences

Sponsor: National Communications System

Objective: To provide recommendations regarding controlling traffic congestion on the Nationwide Emergency Telecommunications Network (NETS)

Summary: A wide range of recommendations for controlling congestion on NETS were developed. Congestion will be a consequence of user demand, the topology of the restored network, and several control factors that influence the relationship between the supply of telecommunications assets and user demand for services. Issues studied and included in the recommendations include the emergency scenario, evolving digital capability, emergency manager requirements, access to NETS, routing algorithms, security, augmentation of NETS, interoperability issues, redundancy routing, and precedence. NETS and its mission must evolve further before final recommendations regarding congestion can be made.

Thesis Directed: K. A. Williams and E. C. Partridge, III, "Logical Design of a Decision Support System to Forecast Technology, Prices and Costs for the National Communications System," Master's Thesis, September 1984.

Title: General Problem Solving: Navy Requirements and Solutions

Investigators: N. R. Lyons, Associate Professor  
K. R. Knott, Research Associate  
Department of Administrative Sciences

Sponsor: Naval Personnel Research and Development Center

Objective: In assigning officers to jobs, the Navy has a general management philosophy. An officer is expected to handle any management situation. General skills are regarded as more important than specialized training. This can mean that an officer may have several months of unproductive learning time before mastering the skills needed for a new assignment. If officers could be given a set of useful general problem solving skills, it is possible that this learning time could be shortened.

This research is a preliminary study with two major objectives. The first is to perform a literature survey of the problem solving and artificial intelligence literature relevant to Navy needs. The second objective is to investigate approaches to problem solving that could be taught to Naval officers for use in their jobs.

Summary: This survey has found a growing interest in the area of problem solving. This interest began with work in cognitive psychology and artificial intelligence in the 1950's and gradually spread to influence education and management. There is little evidence in the literature to indicate that teaching generic problem solving produces improvement in problem solving abilities. One factor complicating this is the lack of adequate definitions of problem solving skills and the lack of test instruments to measure these skills. Some authors suggest that generic problem solving skills are best taught in the context of more conventional courses. The work in teaching generic problem solving is still largely exploratory and unvalidated.

There is a need for both theoretical and applied research in problem solving. Topics of interest include:

1. Design of measures of problem solving skills.

2. Design of course modules in problem solving covering both domain specific and general skills.
3. Experiments where the usefulness of teaching problem solving skills is tested.
4. Studies of computers and human problem solving. These should focus on the computer as a problem environment and ways in which the computer can aid human problem solving.

Title: Analysis of Ship Manpower Readiness

Investigators: W. E. McGarvey, Adjunct Professor  
D. C. Zimmerman, Adjunct Research Instructor  
Department of Administrative Sciences  
W. H. King, BDM Services Corporation/Defense  
Manpower Data Center

Sponsor: Chief of Naval Operations

Objective: Development of longitudinal records for individuals attached to particular ship classes. The records should contain entry and promotional data, and be completely documented.

Summary: The Active Duty Military Master and Loss Edit, maintained by the Defense Manpower Data Center, was used as an initial data base. Quarterly records were concatenated to form longitudinal records for each case. Extractions from the resultant "master file" were made for analytical purposes. The files offer a rich source of data for further analyses.

Publication: W. H. King and D. C. Zimmerman, "Data Base Development for Ship Readiness Analysis," BDM Corporation, November 1984.

Title: Development of a Local Area Material Distribution Plan

Investigator: A. W. McMasters, Associate Professor of Operations Research and Administrative Sciences

Sponsor: Naval Supply Systems Command

Objective: This is a continuing research effort to develop a general material distribution plan for local area support by a large wholesale activity which can then be applied to the Naval Supply Centers at Oakland, San Diego, and Norfolk.

Summary: The approximation for the shortage costs term for the NARF supply support model developed earlier was evaluated to determine whether it could continue to be used when that model is implemented. The approximation was found to be exact if demands were Poisson distributed. In the case of demands being binomially distributed, the accuracy was dependent on how close the parameters  $n$  and  $p$  were for the different customers.

The scheduled delivery model developed earlier was extended to the case where demands at a NARF come from more than one rework production line and all are delivered to simultaneously when a delivery from the local supply center is made. As with the earlier version, no closed form solution could be obtained for the optimal time interval between deliveries. As a consequence, an algorithm using the total expected cost function was needed. Parametric analyses were conducted for several example cases.

The NARF supply support model and the scheduled delivery model were combined into a single model allowing supply support initially from on-site inventories at the NARF and then from the local supply center when the NARF stocks were depleted. The decision variables were the number of units to stock at the NARF and the time interval between deliveries from the supply center. Optimal values of these variables were obtained using an algorithm based on total expected costs for several example cases. The results were compared with the situation where there was no NARF inventory and the results suggested that some on-site stock is preferable.

**Theses Directed:** V. D. Berry, "A Model for NARF Supply Support Which Includes Both On-Site Spares and Scheduled Delivery," Master's Thesis, March 1984.

T. H. Darton, "A Model for Scheduling Deliveries of Repair Parts to Multiple Production Lines at a NARF," Master's Thesis, June 1984.

W. F. Noeggerath, "Evaluations of Approximations for Shortage Costs from Major Customers for a Single Period Inventory Model," Master's Thesis, September 1984.

Title: Stock Coordination Management between NAVELEX and SPCC

Investigator: A. W. McMasters, Associate Professor of Operations Research and Administrative Sciences

Sponsor: Naval Electronics Systems Command

Objective: This is a continuing research effort addressing the question of when inventory management of an item should be transferred from NAVELEX to SPCC.

Summary: Failure rate curves are now being computed annually for each item based on installed populations and random demands. The curves for new items or new versions of older items usually show higher rates for the first two years or so after being installed in the fleet suggesting that the item may not yet be design stable. However, this behavior has been found to be caused instead by the way demands are registered by the supply system. Demands for old designs are recorded as if they had actually been for the new designs in an attempt to create a better forecast of future needs for the new and to speed up phase-out of the old. The subsequent impact of this phase-in and phase-out process on repair parts inventories was identified and suggestions have been made for improving communications between NAVELEX managers of end items and SPCC inventory managers of their repair parts so that the timely availability of the repair parts can be insured.

Theses Directed:

D. R. Smoak, "Multiple Model Electronic Equipment Management by the United States Navy," Master's Thesis, December 1983.

M. F. Sule, "Planning for Spare Parts Support by the Naval Electronic Systems Command," Master's Thesis, June 1984.

Title: Wholesale Provisioning Model for the Provisioning Prototype

Investigators: F. R. Richards, Associate Professor of Operations Research  
A. W. McMasters, Associate Professor of Operations Research and Administrative Sciences  
G. T. Howard, Associate Professor of Operations Research

Sponsor: Naval Fleet Material Support Office

Objective: This is a continuing research effort to develop an improved wholesale provisioning model for the U. S. Navy.

Summary: The Mean Supply Response Time (MSRT) and the Gross Effectiveness (GE) wholesale provisioning models developed last year were evaluated using data for actual provisioning packages from the Ships Parts Control Center (SPCC) and the Aviation Supply Office (ASO). Seven packages were obtained from SPCC and five were obtained from ASO. Comparisons of the performances of these models with the current models used by SPCC and ASO showed the new models to be significantly better (well in excess of the required 5%). The MSRT model was then selected as the model which will be implemented because it considers not only the number of shortages but also the length of time each unit of an item is on back order. It is also an important element of operational availability.

Publication: G. T. Howard, "Wholesale Provisioning Models: Model Optimization," Naval Postgraduate School Technical Report, NPS55-84-028, October 1983.

Title: Research on Cash Management Programs Within the Department of the Navy

Investigator: J. G. San Miguel, Professor of Accounting, Department of Administrative Sciences

Sponsor: Planning and Systems Evaluation Division, Navy Accounting and Finance Center

Objective: The objective of this long-term research program is to investigate the efficiency and effectiveness of the cash management systems within the Department of the Navy. Within this scope it should also be possible to provide an assessment of the potential for fraud, waste, and abuse in the collection, safe-keeping, and disbursement of cash. In addition, the cash management systems employed within DoN can be evaluated for compliance with Department of the Treasury rules and regulations.

Summary: Research is progressing on a number of projects related to cash management. The research programs are being executed by masters thesis students in financial management. One project was completed in September 1984 and four are in process, due for completion in December 1984. The completed research project focused on the implementation of the Department of the Treasury's lock box system within DoN. This empirical study found that significant cost savings could be achieved by the lock box system. The other projects are: an examination of a commercial draft system for replacing imprest funds; an evaluation of the use of travelers checks and credit cards for travel within DoN; a review of the cash management programs within the Marine Corps; and an evaluation of intercorporate electronic drafts for payments to contractors. All field work and data accumulation on these projects has been completed.

Theses Directed:

J. J. Adrzejewski, "An Evaluation of the Application of a Lock Box System Within the Department of the Navy," Master's Thesis, September 1984.

F. C. Alke, "Use of Intercorporate Trade Fund Transfers for Navy Disbursements," Master's Thesis, December 1984.

J. J. Crosby, "Commercial Drafts and Interest Bearing Checking Accounts as Alternatives to Imprest Fund Cash Balances," Master's Thesis, December 1984.

J. W. Farmer, "Cash Management Policy and Procedures Within the United States Marine Corps," Master's Thesis, December 1984.

W. C. Weesner, "An Evaluation of Travelers Checks and Credit Cards for Travel," Master's Thesis, December 1984.

Title: An Evaluation of Leasing as a Financing Strategy Within the Navy

Investigator: J. G. San Miguel, Professor of Accounting, Department of Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: The aim of this proposed research was to evaluate the cost effectiveness of leasing as an alternative financing strategy for the Department of the Navy specifically and the Department of Defense generally. This evaluation of the efficacy of leasing must be twofold: first, from the point of view of DoN in achieving its overall objectives for the program for which the equipment is leased, and second, from the view of the overall operation of the U. S. government.

Summary: Recently both the Department of the Navy and the Department of Defense have initiated plans to lease capital equipment as opposed to the use of appropriated funds to purchase capital equipment. Congress, the General Accounting Office, and the public have expressed concern on this initiative. Although usually far more complex, most leasing arrangements between an owner of capital equipment and someone who wishes to use the capital equipment are viewed as a "rental" arrangement. The DoN's lease arrangements for thirteen ships for its Military Sealift Command are long-term contracts for "transportation services". The length of lease and renewable options, tax benefits, cancellation provisions (DoN guarantees for legal fees and lost interest) involved in the agreements are extremely more complex. An exhaustive study of the extant literature was completed and numerous personal interviews have been conducted with individuals within DoN and others knowledgeable in leasing and the shipbuilding industry. The research is still in progress and should be completed by March 1985.

Thesis Directed: R. E. Ratcliff, "A Framework for the Procurement of Assets Through Leasing Arrangements," Master's Thesis, December 1984.

Title: Computer Network Design

Investigator: Norman F. Schneidewind, Professor of Computer Science,  
Department of Administrative Sciences

Sponsors: Fleet Material Support Office and Naval Supply Systems  
Command

Objective: Develop models, concepts and design methodologies in  
the areas of computer networks and distributed systems  
as applied to the design of the Stock Point Logistics  
Integrated Communications Environment (SPLICE).

Summary: During the past fiscal year the following was  
accomplished:

- 1) Design of a transparent system for user  
communication in SPLICE.
- 2) Development of a model for representing the Session  
Services layer of SPLICE and its communication with  
other network entities.
- 3) Development of a distributed systems design para-  
digm and related design and software metrics.

Publications:

N. F. Schneidewind, "Interface Considerations in  
Computer Networks," Professional Program Session  
Record 25, Wescon/84, Electronic Show and Convention,  
30 October-2 November 1984, Anaheim, CA, IEEE.

N. F. Schneidewind and D. R. Dolk, "A Distributed  
Operating System Design and Data Dictionary/Directory  
for the Stock Point Logistics Integrated Communications  
Environment," NPS Technical Report, NPS54-83-015,  
November 1983.

Conference  
Presentation:

N. F. Schneidewind, "Interface Considerations in  
Computer Networks," in Session 25: "Applications of  
Networks Using Standard Personal Computer Interfaces,"  
Wescon/84 Show and Convention, 1 November 1984,  
Anaheim CA, IEEE.

Theses Directed:

K. D. Chung, "Specification and Implementation of a  
Simulation Model for a Local Area Network (LAN) Design  
in Support of Stock Point Logistics Integrated Communi-  
cations Environment (SPLICE)," Master's Thesis,

B. Schenone, "Performance Evaluation of a Proposed  
Local Area Network Functional Design," Master's Thesis,  
March 1984.

K. Nahit, "The Session Services for Implementation  
of a Local Area Computer Network," Master's Thesis,  
June 1984.

V. Panagiaris, "A Dictionary/Directory System (DDS)  
for the SPLICE System," Master's Thesis, June 1984.

B. A. Frew, "Design Considerations for the Splice  
Session Services Module," Master's Thesis, June 1984.

S. S. Bae, "Considerations for Simulating the Local  
Area Network for SPLICE," Master's Thesis, June 1984.

Title: Computer Performance Evaluation and Modeling

Investigator: Norman F. Schneidewind, Professor of Computer Science,  
Department of Administrative Sciences

Sponsor: Trident Command and Control Systems Maintenance  
Agency, U. S. Navy

Objective: Develop models for analyzing and predicting the  
performance of the IBM VM/370/CMS operating system  
running in IBM 3033 hardware.

Summary: The collection and analysis of performance and user  
characteristic data was continued.

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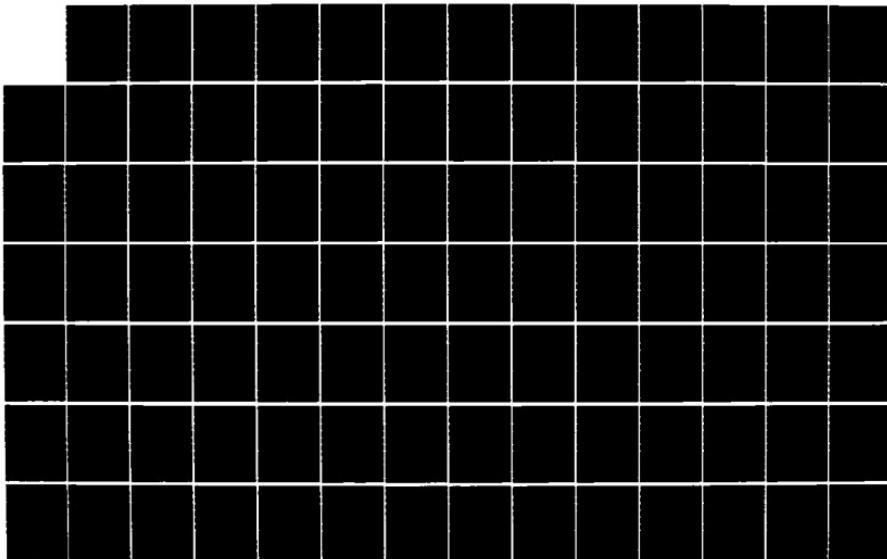
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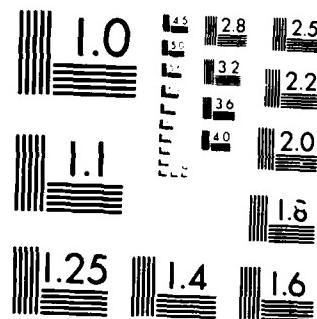
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MICROCOPY RESOLUTION TEST CHART  
ESTIMATED RESOLUTION STANDARDS FOR MICROCOPY

Title: Navy Campus Functional Skills Reading Project

Investigators: T. G. Sticht, Adjunct Research Professor  
L. Armijo, Adjunct Research Professor  
R. A. Weitzman, Associate Professor  
Department of Administrative Sciences

Sponsor: Chief of Naval Education and Training

Objective: To design, develop, implement, and evaluate an integrated computer-based and traditional classroom, paper-and-pencil based reading training program for Navy personnel who enroll in the Navy Campus Functional Skills Program.

Summary: A Navy-life related paper-and-pencil reading instruction program was designed and developed and tried-out. The program delivers three weeks of instruction, three hours a day for a total of 45 hours. Ten hours of computer-based Navy related vocabulary and paragraph training was developed and tried out. A prototype Navy Adult Skills Assessment System: Reading test battery was developed and prepared for norming and scaling using the Rasch and question-guessing program developed by Professor R. Weitzman of the Department of Administrative Sciences.

Conference Presentations:

T. G. Sticht, "Combined Teacher and Computer Based Instruction for Remedial Reading Training with Adults," AERA Annual Meeting, New Orleans, April 1984.

T. G. Sticht, "Knowledge and Text Comprehension," AERA Annual Meeting, New Orleans, April 1984.

Title: Relationship Between ASVAB Test Scores, Moral Waiver Category and Attrition in the Marine Corps

Investigator: T. G. Swenson, Assistant Professor of Management  
Department of Administrative Sciences

Sponsor: Naval Personnel Research and Development Center

Objective: The purpose of this project is to provide an in-depth analysis of the effect of moral waiver enlistment policies on quality and attrition in the Marine Corps.

Summary: The U. S. Marine Corps sets standards of moral character which are necessary for enlistment. Individuals with certain patterns of past behaviors are considered ineligible for service, while those with less severe histories of past behavior may upon review receive a moral waiver and be eligible for enlistment. This report investigates the effects of the moral waiver process on 36 month attrition and adverse attrition. The results suggest that those individuals receiving moral waivers behave in most cases, after controlling for education and mental category, the same as those entering without a waiver. Recommendations are made regarding limiting the use of moral waivers above minor traffic to Mental Category IIIb and above and high school graduate or better.

Publication: T. G. Swenson, "The Effect of Moral Waivers on Marine Corps Attrition," Naval Postgraduate School Technical Report, NPS54-84-030, November 1984.

Title: Cost and Benefits of Older Entry Age Personnel

Investigator: G. Thomas

Sponsor: Office of the Assistant Secretary of Defense (MRA&L)

Objective: To analyze the relationships of military enlistee entry age with: job satisfaction, quality of personnel, career intentions, and personnel costs.

Summary: This preliminary examination of the costs and benefits of older age enlistees identified both differential costs and benefits to the military from older age accessions. Older individuals present a potential for improved quality, technical occupation assignment, organizational commitment, high job satisfaction and low turnover. Attrition costs and dependent costs increases with entry age.

Publication: "The Costs and Benefits of Older Entry Age Personnel: An Initial Analysis", with K. Kocher, Naval Postgraduate School, NPS-54-84-025, September 1984.

Presentation: Forthcoming, ORSA/TIMS conference

Theses Directed: A Preliminary Analysis of the Costs and Benefits of Older Age Enlistees, Susan Barkley, M.S. in Management, March 1984.

An Empirical Analysis of the Decision to Enter Military Service Based on Age at Service Entry, Ronald Stanley, M.S. in Operations Research, June 1983.

Title: Army Reserve Recruiting Study

Investigators: G. W. Thomas, Associate Professor and D. C. Boger,  
Assistant Professor

Sponsor: U. S. Army Recruiting Command

Objective: To construct a study plan for developing U. S.-Army Reserve manpower supply and unit location models.

Summary: We are performing a study consisting of: (a) review of studies and sources of information which examine the various factors that affect Army Reserve recruiting at the unit level or reserve center level; (b) review of current reserve recruiting and unit location methods; and (c) review of current methods of evaluating reserve recruiting.

Based on these reviews and on-site systems analysis, we will prepare a plan for developing operational Army Reserve recruiting/unit location models. These models will be designed to provide forecasts of USAR recruiting performance at unit and higher level, to determine the best mix of resources needed to meet the Army Reserve recruiting mission under various environmental conditions, and to determine location for new units that provide adequate recruiting markets.

Title: Enlisted Supply Model for Older Age Enlistees

Investigator: G. Thomas

Sponsor: U.S. Army Recruiting Command

Objective: Phase I: To review studies and data for developing a model for forecasting enlistment of 22- through 29-year-old youths.

Summary: Currently one phase of a three phase project is underway. Phase one is a critical review of the studies and sources of information which are relevant to this problem. Based on the completion of phase one, a study plan will be developed that incorporates the following elements: a list of the recruiting system and environmental factors that affect recruiting of the 22-through 29-year-old cohort; data collection plan; the format of output reports; the types of analyses (i.e., regression, factor or discriminant analysis, linear programming, etc.) to be used to construct the final models; the format, sequence, and method for the model user for "controlling" the explicit supply model; and a plan to validate the model, the prediction algorithms, and the methodology. Phase three will be the development of an operational model.

Title: Development of an Army Billet Cost Model

Investigator: G. Thomas

Sponsor: U.S. Army Research Institute

Objective: To develop a life cycle billet cost model for the U.S. Army.

Summary: This research analyzed existing life cycle manpower cost models and will estimate Army -specific manpower costs by rank, years of service, and MOS. It will build an Army billet cost model for the enlisted force which will provide Army policy analysts with specific cost information as input for analyzing manpower issues and programs and cost tradeoffs between manpower and hardware.

Title: Army Unit Capability Study

Investigators: G. Thomas, K. Kocher

Sponsor: U.S. Army TRADOC System Analysis Activity

Objective: To provide TRADOC Research Element Monterey (TREM) assistance with the maintenance and development of Army models of unit effectiveness.

Summary: The results of this effort are two fold: (1) we conducted research in the area of unit effectiveness/unit readiness modeling; and (2) we assisted TREM in its educational responsibilities as TRADOC proponent for the AMORE (Analysis of Military Organizational Effectiveness) methodology. We identified and recommended potential improvements to the AMORE model. Points of contact with the functional schools and centers were established to assist users in translating their problems into potential thesis topics for student examination. Principal researchers made community research needs in the specific area of AMORE and the general area of unit effectiveness known to students and faculty at NPS through seminars and other informal means. Principal researchers are assisting TREM in conducting a workshop on AMORE.

Publication: Analysis of Military Organizational Effectiveness (AMORE) User's Handbook, In progress, September 1984.

Theses Directed: Application of AMORE (Analysis of Military Organizational Effectiveness) model to Charles F. Adams Class Guided Missile Destroyer, Paul Susalla, M.S. in Management, in progress.

A Sensitivity Analysis of the AMORE (Analysis of Military Organizational Effectiveness) Model, Edward Negrelli, M.S. in Operations Research, in progress.

Title: Project Interest Inventory: A Study of the Effects of Offering Interest Measurement with the ASVAB in the DOD Student Testing Program

Investigator: N. A. Nieboer-Turpin, Adjunct Research Professor of Psychology, Department of Administrative Sciences

Sponsors: Office of the Assistant Secretary of Defense .  
(Manpower, Installations and Logistics)  
Director of Accession Policy and Navy Personnel  
Research and Development Laboratory

Objective: To determine whether offering an interest inventory in conjunction with the Defense student testing program will increase the quantity and "quality" of juniors and seniors tested with ASVAB.

Summary: The effort requires securing the testing of about 50,000 high school juniors and seniors, coordination of efforts among various civilian and military organizations, summarizing the results from a variety of viewpoints, and offering recommendations about potential expansion or implementation. This project began in September 1983 and continues throughout FY85.

Title: Evaluation of Modified Commercial Aptitude Testing as a Supplement to Defense Student Testing

Investigator: N. A. Nieboer-Turpin, Adjunct Research Professor of Psychology, Department of Administrative Sciences

Sponsors: U. S. Army Recruiting Command  
U. S. Air Force Recruiting Service  
U. S. Marine Corps

Objective: To provide a thorough evaluation of the modified supplemental student testing program, with recommendations for future improvements in Defense student testing programs.

Summary: Arrangements for continued testing in the Midwest and West were completed in the first quarter, and testing proceeded as planned. Final report from the testing organization was received. Final evaluations are underway, pending receipt of final reports from the recruiting field level of two sponsors.

Conference Presentations: N. A. Nieboer Turpin, "Modified Commercial Aptitude Testing Pilot Project," Joint Service Selection and Classification Working Group, San Antonio, Texas, January 1984; and, JSSCWG plus observers, Washington, DC, July 1984.

Title: Evaluation of Efforts to Supplement the DOD Student Testing Program with Commercial Aptitude Tests

Investigator: N. A. Nieboer-Turpin, Adjunct Research Professor of Psychology, Department of Administrative Sciences

Sponsor: Office of the Assistant Secretary of Defense (Manpower, Installations and Logistics), Director of Accession Policy

Objective: To provide a detailed evaluation of the supplemental commercial student testing program, with recommendations for future application to improve the Defense student testing program.

Summary: Defense-subsidized commercial aptitude testing was conducted in the Midwest, West, and New England during 1982-1983. Information about the program was obtained from the testing agencies, school officials, students, and the Services. Public perceptions of the program were favorable, students expressed interest in learning about Defense training and education programs, and Service recruiters found the detailed information provided by the leads helpful. Favorable interim recommendations led to the continuation of a modified supplemental aptitude testing pilot project in School Year 1983-1984.

Presentation: N. A. Nieboer Turpin, "Evaluation of Supplemental Commercial Aptitude Testing," Joint Service Selection and Classification Working Group, San Antonio, Texas, January 1984.

Title: Estimation of the Knowledge Distribution from the Response Distribution of a Multiple-Choice Test

Investigator: Ronald A. Weitzman, Associate Professor of Psychology, Department of Administrative Sciences

Sponsor: None

Objective: To estimate the proportion of people who know each possible integral number of multiple-choice items from the frequency distribution of total number-correct test scores.

Summary: The standard correction for guessing yields an estimate of the expected number of items known ( $\bar{K}$ ) from the number answered correctly on a multiple-choice test. This expected number may be considered to be the mean of the distribution of the number of items known by people in each number-correct score group. The sum of the separate distributions for all number-correct score groups provides an estimate of the knowledge distribution of the test. I have developed this as well as alternative estimation procedures and found that this one has the fewest computational problems.

Title: Use of the Rasch Model in Selective Testing

Investigator: Ronald A. Weitzman, Associate Professor of Psychology, Department of Administrative Sciences

Sponsor: None

Objective: To use the Rasch model to estimate the correct-response probabilities of selective-test items for people in each successive score group of a reference test.

Summary: A selective test consists of the presentation of one item at a time till a selection decision is possible with preset error probabilities of acceptance or rejection. Current selective tests tend to violate the assumption of "local independence" required by the use of the sequential probability ratio as the statistical vehicle of the tests. Use of the Rasch model will tend to assure the satisfaction of this assumption. I have made sufficient progress on this project to submit a proposal to the NPS Foundation for completion of the work.

Title: Use of the Rasch Model in Multiple-Choice Testing

Investigator: Ronald A. Weitzman, Associate Professor of Psychology, Department of Administrative Sciences

Sponsor: None

Objective: To take account of the effect of guessing in Rasch model descriptions of responses to multiple-choice items.

Summary: I have developed procedures for parameter estimation, scoring, and evaluating the goodness-of-fit in applications of the Rasch model to multiple-choice test data; I have also prepared computer programs that execute these procedures.

Publications: I am completing a book that describes my work in this area and have completed a paper that will appear in the Proceedings of this year's meeting of the Military Testing Association.

Conference Presentations: I presented papers on this work at the annual meeting this year of the Psychometric Society and the Military Testing Association.

Title: Development and Support of DPPO Productivity Research Program

Investigator: D. R. Whipple, Professor of Economics and Systems Analysis, Department of Administrative Sciences

Sponsor: Defense Productivity Program Office

Objective: This proposal involves continuing conceptual support for DPPO's developing program of productivity research, as well as direct participation in a number of the specific research projects by Professor Whipple, and his direction of a number of related theses at NPS.

Summary: The Defense Productivity Program Office (DPPO) has significantly increased and modified its internal research program in the past year. In particular, major research efforts in Productivity Measurement, Workforce Motivation, and Efficiency Reviews and Operational Improvement are either underway or planned. Professor Whipple has been providing input to the cognizant personnel to assist in structuring and evaluating these efforts. The present proposal is to continue these activities and to participate more directly, both personally and through his thesis definition and direction efforts, in these DPPO research activities.

The objectives of the research include:

1. To provide on-site productivity research guidance and consulting to DPPO staff on a regular basis.
2. To identify and perform specific research tasks which will satisfy a portion of the input required to DPPO's research program.
3. To identify and develop ways in which DPPO research needs may be addressed in NPS productivity-related courses and curriculum development.

In support of these objectives, Professor Whipple solicited nine thesis students to work on productivity-related projects during this year; analyzed and provided feedback to DPPO staff on the appropriate form of their efforts in the Workforce Motivation, Organizational and Operational

Improvements, Efficiency Reviews, and Training Implications areas; and provided guidance for the DPPO internal strategic planning effort.

- Conference Presentation: D. Whipple and J. Tweeddale, "Policy Issues: The Role of Productivity Enhancement," APPAM (Association for Public Policy Analysis and Management), Philadelphia, PA, 17 October 1983.
- Theses Directed: D. Bisgnano, "Worker Motivation: A Review for DOD Policy Implications," Master's Thesis, December 1983.
- M. Galdun, "Suggestions for Development of Computerized Productivity Measures in Military Outpatient Clinics," Master's Thesis, March 1984.
- J. Hetsko and R. Moran, "OMB Circular A-76, Efficiency Reviews and Performance Measurement in the DOD Health Care Delivery System," Master's Thesis, June 1984.
- E. Lenio, "Introduction of Uncertainty Techniques into the Productivity Investment Fund," Master's Thesis, March 1984 (co-advisor).
- D. Grahlman, "A Methodology for Benefit Analysis of CAD/CAM in USN Shipyards," Master's Thesis, March 1984 (co-advisor).
- R. Adams and T. Warwoda, "Training Implications for Management Productivity in Medical Logistics," Master's Thesis, December 1984.
- J. Norton, "A Study of Excellence in Naval Health Care," Master's Thesis, December 1984.

**DEPARTMENT  
OF  
OPERATIONS RESEARCH**

## DEPARTMENT OF OPERATIONS RESEARCH

Operations Research (OR) is a multi-disciplinary field, a fact which is reflected in the variety of areas covered by the sponsored research of the faculty. The applications areas include combat models, manpower and personnel, supply and logistics, tactical analysis, and command, control and communications.

### MATHEMATICAL PROGRAMMING

Professors Brown and Wood of Operations Research and Bradley of Computer Science continue their research programs in the theory and application of large scale optimization. They have developed new approaches for solution of large scale network reliability models. As a result of this research program, the Naval Postgraduate School continues to have one of the most powerful existing optimization laboratories. The National Research Council of the National Academy of Sciences supported a Postdoctoral Fellow, Richard Rosenthal, to work with Professor Brown.

### STOCHASTIC MODELING/STATISTICS

Professors Gaver and Jacobs, under sponsorship by ONR and NSF, continue development of stochastic models and statistical data analysis methodology and repair, and environmental prediction. The latter work is partially sponsored by NEPERF. A National Research Council Postdoctoral Fellow, Charles Silio, worked with Professor Gaver during 1984.

Professor Lewis continued to derive properties for new stochastic point processes and time series models. In addition, new methods for simulating a broad class of stochastic point processes have been discovered. Applications of these processes to oceanographic phenomena are being pursued. This work is supported by ONR. National Research Council Fellow, Edward McKenzie, worked with Professor Lewis during 1984.

Professor Esary has continued his studies in reliability. Professor Larson and Professor Jayachandran of Mathematics have continued analysis of spectrometric data from oil analysis under sponsorship of the DOD.

Naval Underseas Warfare Engineering Station. Professors Shubert and Washburn, under ONR sponsorship, developed an efficient minefield simulator for the IBM/PC.

#### COMBAT MODELING

Professors Parry and Hartman continue to develop a computer simulation model of airland combat for the U.S. Army Training and Doctrine Command.

#### COMMAND, CONTROL, AND COMMUNICATIONS

Professors Sovereign, Hughes, and Fischback are investigating the measurement of the effectiveness of command and control procedures hardware and software. Professor Taylor is conducting a comprehensive review of the use of operations research by the Soviets in automated troop control. From this review, lessons for C3 countermeasures are being drawn. Professors Sovereign, Yee, and Professor Wozencraft of Electrical and Computer Engineering are developing algorithms to re-route calls through the AT&T network in the event of a national disaster. This work is sponsored by DCA.

#### TACTICAL ANALYSIS

The tactical analysis division of ONR has continued to fund a long-term project led by Professor Washburn. Professor Eagle continued a project whose goal is discovery of efficient anti-submarine search tactics. Professors Forrest and Shudde continued their work in hand-held computer evaluation.

Professor Andrus, under a separate contract, continued his evaluation of contractor support for the tactical analysis team.

#### MANPOWER PERSONNEL

Professor Read initiated a project to forecast manpower loss rates that appear in Marine Corps manpower planning models. The work is sponsored by the Naval Personnel Research and Development Center.

Professor Milch, under sponsorship of the Navy, initiated a project to evaluate changes to Naval Officer career paths. Professor Milch also continued to direct the U.S. Army Manpower/Personnel Project involving faculty and Army students to work on specific Army manpower models under Army MILPERCEN sponsorship.

#### VOICE INPUT TO COMPUTERS

Professor Poock continues his work in adapting available hardware to perform voice input of data to computers, with applications in Command, Control, and Communications. This work is sponsored by Naval Electronics Systems Command.

#### LOGISTICS AND SUPPLY

Professors Richards, McMasters, and Howard have continued development and testing of alternative wholesale models for the Navy's inventory control points with the completion of the development of models for the provisioning of new weapons systems. The Naval Supply Systems has adapted for implementation the provisioning model which the investigators proposed. Their research is sponsored by the Naval Fleet Material Support Office. Professor McMasters continued his research, sponsored by Naval Supply Systems Command, into material distribution systems for local area support by large wholesale activities.

Title: Nonlinear Optimization of Sortie Allocaton

Investigator: G. G. Brown, Professor of Operations Research

Sponsor: U. S. Air Force

Objective: To develop, implement, and install a nonlinear optimization model of sortie allocation for determining nonnuclear munitions mix at theatre level.

Summary: A nonlinear model has been formulated which exploits elastic features of an optimization system developed by the principal investigator. The model has been implemented and installed on IBM main frame computers in the Pentagon, and on DEC VAX minicomputers at various locations. The system is designed to support virtually instant-turnaround modelling, even though the models posed are relatively large and difficult to solve. Scenarios are constructed and solved in real-time by an evaluation team representing theatre commanders and headquarters analysts. Such plays of the system are used to evaluate nonnuclear munition procurement and stockpiling plans at the theatre level. In addition, strategic studies are conducted using the model as a high-resolution surrogate for actual air sortie simulation which yields reliable estimates of munitions expenditure over time under various conditions of weather, opposition, target dispersion and condition, and so forth.

Conference Sponsored: As part of this research, representatives of the major services were invited to the Naval Postgraduate School for an informal exchange of ideas and procedures now in use and forecast for future use in supporting procurement plans for conventional ammunition and ordnance. This was the first such inter-service exchange of ideas and technology in the memory of the participants.

Publications: A report is under preparation summarizing the findings of this project, and of related work by other researchers.

Thesis Directed: P. Lord, "An Examination of the United States Air Force Optimal Nonnuclear Munitions Procurement Model," Master's Thesis, October 1982.

Title: Large-Scale Optimization

Investigators: G. G. Brown, Professor of Operations Research  
G. H. Bradley, Professor of Computer Sciences

Sponsor: Office of Naval Research

Objective: Develop theory and algorithms for solution of large-scale optimization models.

Summary: The Naval Postgraduate School research program in large-scale optimization has continued with progress on several fronts. Optimization of generalized networks, networks with gains, fixed charge networks, and imbedded networks has received further attention. Such models can now be solved nearly as efficiently as pure networks. Large-scale nonlinear and mixed integer models can now be solved in real time, with model generation facilities and report extraction tools permitting rapid response to analyst queries. New decomposition and relaxation methods for very large models have yielded extremely efficient solutions of complex mixed integer problems. More important, new theoretical insight has been gained in the convergence properties of these approaches.

Publications:

G. Brown, R. McBride and K. Wood, "Extracting Embedded Generalized Network Problems from Linear Programming Problems." Mathematical Programming (forthcoming).

G. Brown, G. Graves and M. Honczarenko, "Design and Operation of a Multicommodity Production/Distribution System Using Primal Goal Decomposition," Management Science (forthcoming).

G. Brown and R. McBride, Solving Generalized Network Problems," Management Science, 30 (1984), pp. 1497-1523.

G. Brown and B. Shubert, "On Random Binary Trees," Mathematics of Operations Research, 9 (1984), pp. 43-65.

G. Brown, G. Graves and D. Ronen, "Scheduling Ocean Transportation at Crude Oil," (forthcoming)

J. Taylor and G. Brown, "Annihilation Prediction for Lanchester-Type Models of Modern Warfare," Operations Research, 31 (1983), p. 752.

G. Brown and G. Graves, "Real-Time Dispatch of Petroleum Tank Trucks," Interfaces, (forthcoming).

G. Brown and W. Wright, "Automatic Identification of Embedded Network Rows in Large-Scale Optimization Models," Mathematical Programming, 29 (1984), pp. 41-56.

G. Bradley, G. Brown and G. Graves, "Structural Redundancy in Large-Scale Optimization Models," in Redundancy in Mathematical Programming, M. Karwan et al., eds., Springer Verlag, (1983).

R. Goren, D. Bausch and C. Brown, "Determination of Optimal Aircraft Mix in Air Force," NPS Technical Report, NPS55-81-025, December (1981).

G. Brown, G. Bradley and G. Graves, "Review of the Computational Aspects of the TBS Regulatory Analysis Financial Model," Electric Power Research Institute Technical Report, September (1981).

G. Brown and W. Wright, "Automatic Identification of Embedded Structure in Large-Scale Optimization Models," appears in Large-Scale Linear Programming, G. Dantzig, M. Dempster and M. Kallio, eds., International Institute for Applied Systems Analysis, Laxenburg, Austria, (1981) pp. 781-808.

G. Brown and D. Thomen, "Automatic Identification of Generalized Upper Bounds in Large-Scale Optimization Models," appears in Large-Scale Linear Programming, G. Dantzig, M. Dempster and M. Kallio, eds., International Institute for Applied Systems Analysis, Laxenburg, Austria, (1981) pp. 747-780.

Conferences:

G. Brown, G. Bradley and A. Geoffrion, "Capital Expenditure Planning: A Telephone Industry Application" TIMS/ORSA, San Francisco, CA, May 14, 1984.

G. Brown, R. McBride and K. Wood, "Extracting Embedded Generalized Network Problems from General LP Problems" TIMS/ORSA San Francisco, CA, May 14, 1984.

G. Brown, G. Bradley and R. Clemence, "Implementation of Structure Modeling For Optimization" TIMS/ORSA Dallas, TX, November 27, 1984.

G. Brown, "Mathematical Programming Systems ---Where do we go from here?" panel presentation TIMS/ORSA Dallas, TX, November 27, 1984.

G. Brown, R. Rosenthal and C. Stanić, "Shipment Planning with Multi-commodity Optimization," TIMS/ORSA Dallas, TX, November 28, 1984.

G. Brown, G. Bradley, and R. Clemence, "Structured Modeling for Optimization" American Institute of Chemical Engineers, San Francisco, CA, November 19, 1984.

Theses Directed: R. Clemence, Jr., "LEXICON: A Structured Modeling System For Optimization", Master's Thesis, June 198 .

C. Stanić, "Design and Solution of an Ammunition Distribution Model by a Resource-Directive Multicommodity Network Flow Algorithm," Master's Thesis, June 1984.

D. Theune, "A Micromputer-Based Linear Programming System," Master's Thesis, October 1983.

M. Finley, "An Extended Microcomputer-Based Network Optimization Package," Master's Thesis, October 1982.

D. Bausch, "Computational Advances in the Solution of Large-Scale Set Covering and Set Partitioning Problems," Master's Thesis, October 1982.

P. Lord, "An Examination of the United States Air Force Optimal Nonnuclear Munitions Procurement Model," Master's Thesis, October 1982.

Title: Stochastic Modelling and Data Analysis

Investigator: P. A. Jacobs, Associate Professor of Operations Research

Sponsor: National Science Foundation

Objective: To develop and study probabilistic models

Summary: The emphasis the past year has been on approximating distributions. Normal approximations for the response time of a job in a processor-shared computer system model were developed and studied. Exponential Approximations for the distribution of time until a combination of random loads first exceeds the strength of a structure were also studied.

Publications: D. P. Gaver and P. A. Jacobs. Processor-Shared Time-Sharing Model in Heavy Traffic. (forthcoming)

P. A. Jacobs. First Passage Times for Combination of Random Loads. (Forthcoming)

Conference Presentation: P. A. Jacobs, D. P. Gaver, S. Pornsuriya. "Waiting Time Distribution in Processor-Shared Computing Systems." Joint National Meeting ORSA/TIMS, Orlando, FL, November 1983.

Theses Directed: S. Pornsuriya. "Normal Approximation for Response time in a Processor-shared Computer System Model." Master's Thesis, March 1984.

J. K. Noh, "A Simulation Study of Models for Combinations of Random Loads." Master's Thesis, September 1984.

Title: Oil Analysis Procedures

Investigators: H. J. Larson, Professor of Operations Research  
T. Jayachandran, Professor of Mathematics

Sponsor: Air Force Logistics Center

Objective: Long term objectives include the generation of useful computer based procedures for the tri-service Joint Oil Analysis Program. Current period objectives included the Test and Evaluation of the Air Force's Comprehensive Engine Management System, Phase IV, (CEMS IV), consideration of the feasibility of upgrading the service's old atomic emission spectrometers, and initial study of the acceptance testing of the new Portable Wear Metal Analyzer.

Summary: Our major contribution this year was the completion of the Test and Evaluation of CEMS IV, including the isolation of possible program bugs and suggested changes in the statistical algorithms it employs for oil analysis. We also participated in the discussions of converting the CEMS IV code for use on the Zenith Z-100 micro-computer which has been selected for installation at Air Force Bases. We made recommendations regarding a proposed upgrade of the Air Force's older atomic emission spectrometers. In addition, we attended demonstrations of the new Portable Wear Metal Analyzer and made numerous suggestions for the acceptance testing of this instrument.

Title: U. S. Army Manpower/Personnel Project

Investigator: Paul R. Milch, Professor of Operations Research

Sponsor: U. S. Army Military Personnel Center

Objective: To establish a research project involving both faculty and Army students to work on Army personnel/manpower problems.

Summary: The following problems suggested by the sponsor were investigated:

1. The Personnel Readiness Indicator Model. An initial model was constructed that has the potential to predict the future personnel readiness of Major Commands (MACOM's) of the U.S. Army. This prototype model involves only soldiers with one of the several hundred military occupational specialties (MOS's) located at five of the most important MACOM's. The model involves forecasting future end strengths via a Markov Chain model and distributing new accessions (and personnel making permanent change of station moves) to MACOM's in an optimal sense. "Optimal" here means maximizing the smallest percentage fill among all skill level personnel in all five MACOM's, subject to availability of personnel and Army requirements about minimum (and maximum) percentage fills. "Percentage fill" refers to the ratio of available to authorized numbers of personnel in each skill level and MACOM.
2. The Airborne Model. An initial model was constructed to predict future training requirements in the Airborne Community for personnel with secondary qualification indicators (SQI's). This prototype model involves soldiers with one of only two of the about two dozen career management fields (CMF's) in the Airborne Community. The model computes the required number of personnel to be trained of the three Airborne SQI's: parachutist, ranger and special forces, the next several years, subject to limited training class sizes and overall training budget size.  
A complete model involving all thirty-one CMF's of the Airborne Community was constructed to predict future training requirements of parachutists, rangers

and special forces personnel. This computer model, written in the APL language, employs Markov Chain Theory to forecast future inventories and uses Marginal Analysis to determine the optimal number of soldiers with certain skill levels who should enter special (parachutist, ranger and special forces) training in future years. The goal is to minimize the maximum percentage of shortage of personnel relative to authorizations.

3. The Army Officer Promotion Plan. The five year Army Officer promotion plan for the Officer Personnel Management Directorate (OPMD), which includes all Combat Arms, has been produced manually over the years by MILPERCEN. This is an extremely lengthy process involving hundreds of interrelated calculations that must be repeated every time the value of a single parameter is altered. This entire procedure has been automated using the LOTUS 1-2-3 Spreadsheet software system on the IBM PC. This automation should enable MILPERCEN not only to produce the Five Year Officer Promotion Plan much more efficiently, but also to explore hypothetical developments and experiment with various scenarios with practically instantaneous responses from the electronic spreadsheet.

Theses Directed:

C. S. Thomas, "Forecasting U.S. Army Major Command Readiness Based on Enlisted Personnel Strength", Master's Thesis, December 1983.

D. B. Chung, "The Forecasting of Future Inventory and the Optimization of Training Requirements within the Airborne Community", Master's Thesis, December 1983.

D. T. Koutianoudis, "Manpower Modeling in the Airborne Community of the United States Army", Master's Thesis, September 1984.

H. T. Styron, "The Application of Micro-computer Spreadsheets to Produce the U. S. Army Five Year Field Grade Officer Promotion Plan", Master's Thesis, December 1984.

Title: Research in Simulation/Wargaming Methodology for Interdiction

Investigator(s): S. H. Parry, Associate Professor of Operations Research  
J. K. Hartman, Associate Professor of Operations Research  
A. L. Schoenstadt, Associate Professor of Mathematics

Sponsor: U. S. Army TRADOC Operations Research Activity

Objective: To develop modelling methodology appropriate for the very large scale but sparsely populated rear areas involved in the interdiction battle and for the command and control of the battle force. To apply these methodologies in the construction of a simulation/war gaming model focusing on two sided interdiction. This is the first of a multi-year effort.

Summary: The ultimate goal of the research effort is to develop a systemic combat simulation of the airland environment for a Corps sized operation. The initial year of research focused on development of systemic decision algorithms and a generalized value system. Soviet troop control models were developed to determine the tactical and logistical feasibility of an operations plan. The model was demonstrated for the scenario of a deliberate river crossing operation by a Soviet motorized rifle division. A major research task initiated during this year was the identification and description of network coordinate systems within the Airland Research Model. Network structures and network flow optimization algorithms were identified for modelling tactical movement, logistics transportation, and communications flows. Network connectivity algorithms were used to describe the hierarchical unit organization space and the time-varying combat task force organization space. Network planning models were applied to generating and evaluating alternatives for the command and control process. A detailed model of a unit's planning process for ammunition resupply was developed. The model can be applied to either "pull" or "push" resupply systems and is designed to work in parallel at each of the units in a hierarchy from Corps level supply down to the consuming units in combat. The model has been applied to a Soviet ammunition planning example as an initial test. Initial methodology to incorporate a generalized value system into the model was developed. The methods involve the use of present and future worth computations, as well as

Summary (Cont'd): techniques for inputting values to units (such as support units) based on values of units they support. Methods were developed for representation of communications which concentrated on algorithms for representing the networks and flows involved, on models for decisions associated with selection of communication means, and on decision rules for reallocation of communications assets in the face of failure, destruction or degradation.

Publications: S. Parry, J. Hartman, A. Schoenstadt, "Airland Research Model," Proceedings of the 52nd Military Operations Research Symposium, July 1984.

S. Parry, "A Research War Game to Investigate Interdiction," Proceedings of the Military Simulation Applications Conference, November 1983.

Conference Presentations: S. Parry, "Airland Research Model," 52nd Military Operations Research Symposium; July 1984.

S. Parry, "A Research War Game to Investigate Interdiction," Military Simulation Applications Conference, November 1983.

Theses Directed: D. R. Alexander, "Airland Battle Interdiction Model - Corps Communication Module," Master's Thesis June 1984.

M. D. Balderman, "A Division Level Communications Module for Use in the Airland Model," Master's Thesis June 1984.

D. C. Brown, "A Partial Model of Ammunition Resupply Planning and Application to Soviet Ammunition Resupply Planning (U)," Master's Thesis, June 1984.

J. J. Manzio and J. M. Hughes, "A Surrogate for Soviet Division Level Automated Troop Control System," Master's Thesis, June 1984.

R. P. Frisbie, "Methodology Demonstration for Relative Value Determination of Soviet Troop Control System Elements," Master's Thesis, June 1984.

T. A. Gandy, "Allocation of Intelligence Collection Assets for the Airland Battle," Master's Thesis, June 1984.

Title: Navy Officer Corps Management Studies

Investigator: P. R. Milch, Professor of Operations Research

Sponsor: Director, Military Personnel Policy Division  
Office of the Deputy Chief of Naval Operations,

Objectives:

- (a) To critically review current officer career paths in the Surface Warfare, the Aviation Warfare and the Nurse Corps communities with special regard to permanent change of station (PCS) moves.
- (b) To determine the best methodology for measuring and evaluating the effectiveness of recent changes to the Surface Warfare Officer (SWO) career path.
- (c) To initiate work toward development of a network flow model representing SWO career paths with the ultimate goal of providing community managers with a tool to make rapid assessment of likely future consequences of proposed changes in the career paths of SWO's.

Summary:

- (a) Network representation of career paths within the Surface Warfare, Aviation Warfare and Nurse Corps communities were developed and related to PCS moves. Geographic and historical billet analyses were conducted in order to examine possible alterations in tour sequences and, thereby, reduce the number of PCS moves. Other PCS related topics specific to each of the above three communities were also examined. Some alternatives to the career path were recommended in each community.
- (b) This topic was investigated by Dr. Robert F. Morrison of the Navy Personnel Research and Development Center, San Diego, CA.
- (c) Network representations of all significant career pathways in the Surface Warfare (as well as in the Aviation Warfare and Nurse Corps) Community was accomplished using an idea developed in the Aviation Officer Requirement Study by Information Spectrum, Inc. (submitted to Program Director, Operations Research, Mathematical and Information Sciences Division, Office of Naval Research, Contract No. N00014-81-C-0368, Report No. V-2693-01, dated 31 May 1982). This project is continuing.

- Theses Directed:
- R. H. Howe, "The Effect of PCS Policy Changes on Surface Warfare Officer Career Development", Master's Thesis, December 1984.
- W. T. Ballew, "A Cost Efficiency Study of Aviation Officer Career Patterns and Permanent Change of Station Movements", Master's Thesis, December 1984.
- E. A. Poland, "Effect of Permanent Change of Station (PCS) Policy Changes on Nurse Corps Career Development", Master's Thesis, December 1984.

Title: Computational Statistical Tools for Weather Forecasting

Investigators: D. P. Gaver, Professor of Operations Research and  
P. A. Jacobs, Associate Professor of Operations Research

Objective: To develop computational-statistical methodology for use in analysis of weather data and for forecasting of weather conditions.

Summary: The use of data analytic and statistical techniques to aid in single-station, short-horizon prediction of environmental conditions has been studied. Non-linear (logistic) classical and robust regression techniques have been used to predict next-day low stratus at an airport (Moffett Field) on a single station basis. A similar study of single station wind speed predictability at Moffett Field has been initiated.  
  
An initial formulation and solution has been given of a single two-action decision problem relevant to tropical typhoon evacuation at a fixed store location.

Publications: D. P. Gaver and P. A. Jacobs. Low-level stratus prediction using binary statistical regression. A progress report using Moffett Field data. Naval Postgraduate School Technical Report, NPS 55-83-004, pp. 77.  
  
D. P. Gaver and P. A. Jacobs. Low-level stratus prediction using binary statistical regression: a summary of results using Moffett Field data. Preprint Volume for the Eighth Conference on Probability and Statistics in Atmospheric Sciences, American Meteorological Society, 1983, pp. 148-152.  
  
P. A. Jacobs and D. P. Gaver. An exploratory analysis of wind speeds measured at Moffett Field for 1958. (forthcoming)

Conference Presentation: D. P. Gaver and P. A. Jacobs. Low-level stratus prediction using binary statistical regression: a summary of results using Moffett Field data. Eighth Conference on Probability and Statistics in Atmospheric Sciences, Hot Springs, Arkansas, Nov. 1983.

Title: Stochastic Modeling and Data Analysis

Investigators: D. P. Gaver, Professor of Operations Research  
P. A. Jacobs, Associate Professor of Operations Research

Sponsor: Office of Naval Research

Objective: To develop, apply, test, and validate new methods of statistical data analysis and probability modeling for solving problems arising in applications, with special reference to problems in the Navy, and the government and military in general.

Summary: Extensive development of theory and methodology and software for analysis of data utilizing a robust a robust parametric empirical Bayes model (RPEB) for point events (Poisson processes). Simulations validate reliability problems provide applications. A model for processor-shared computing with multi-type war analyzed using diffusion approximations.

A model for the performance of communication systems allowing "collisions" and destruction, or delay, as in the busy signal system of telephone, war analyzed by generating function methods.

Title: Rate Generation Methodology for Manpower Models

Investigator: R. R. Read, Professor of Operations Research

Sponsor: Naval Personnel Research and Development Center

Objective: To explore the usability of the James-Stein parameter estimating structure for the problem of forecasting various and numerous loss rates that appear in Marine Corps manpower planning models. The initial work is limited to aggregates of categories of officers.

Summary: The structure introduced by James and Stein creates a global systematic way to treat the problem of estimating a large number of parameters in situations where individual estimates of these parameters cannot be supported by a large number of cases. Efficacy measures of global effectiveness are improved (although some individual cases may suffer). Because of the pioneering work of James and Stein, others have structural alternative schemes based on somewhat different principles but having a similar effect. The past half dozen or so years has seen a proliferation of these schemes, often referred to as "shrinkage methods."

Our work involves the modification of the general James-Stein idea to the peculiarities of manpower planning loss rates. This has been done, but testing the usefulness was delayed because the manpower data tapes did not arrive until mid August.

Title: Underwater Sonar Array Calibration Control

Investigator: R. R. Read, Professor of Operations Research

Sponsor: Naval Undersea Weapons Engineering Station

Objective: To develop a crossover data analysis methodology that will identify arrays whose location and orientation may have changed since the last survey. To develop decision values for choosing among the several possible actions when tracking "mismatches" occur.

Summary: The algorithm developed and tested last year has been replaced by a new one which uses a different technique for finding the optimum value of the figure of merit. The new method is supported by a mathematical theorem that guarantees convergence to the optimum values. The testing of this method using real data has been successful (in the mathematical sense) in all cases. Convergence to the optimum values is rather slow, however.

This testing also revealed that the figure of merit can be a rather flat surface in some cases (two of our nine test cases). Because of this, a third method, called the principal components method, has been introduced. Testing of this method thus far has produced satisfactory and usable results. This method is expected to work well when the track is essentially a straight line in the crossover region.

Publications: R. R. Read, "Interim Report on Task 83-7, NUWES, NPS Technical Report, NPS 55-83-031 PR, October 1983.

R. R. Read, "New Algorithm to Estimate Displacement and Orientation Corrections", private written communication to NUWES, Code 50, September 1984

Thesis directed: C. D. Main, "Alternative Models for Calculation of Elevation Angles and Ray Transit Times for Ray Tracing of Hydrophonic Tracking Data", Master's Thesis, September 1984.

Title: Wholesale Provisioning Model for the Provisioning Prototype

Investigators: F. R. Richards, Associate Professor of Operations Research  
A. W. McMasters, Associate Professor of Operations Research and Administrative Sciences  
G. T. Howard, Associate Professor of Operations Research

Sponsor: Naval Fleet Material Support Office

Objective: This is a continuing research effort to develop an improved wholesale provisioning model for the U. S. Navy.

Summary: The Mean Supply Response Time (MSRT) and the Gross Effectiveness (GE) wholesale provisioning models developed last year were evaluated using data for actual provisioning packages from the Ships Parts Control Center (SPCC) and the Aviation Supply Office (ASO). Seven packages were obtained from SPCC and five were obtained from ASO. Comparisons of the performances of these models with the current models used by SPCC and ASO showed the new models to be significantly better (well in excess of the required 5%). The MSRT model was then selected as the model which will be implemented because it considers not only the number of shortages but also the length of time each unit of an item is on back order. It is also an important element of operational availability.

Publication: G. T. Howard, "Wholesale Provisioning Models: Model Optimization," Naval Postgraduate School Technical Report, NPS55-84-028, October 1983.

Title: Radio Shack TRS80 PC-2 Calculator Manual for ASW Operations

Investigator: R. H. Shudde, Associate Professor of Operations Research

Sponsor: Navy Tactical Support Activity

Objective: To develop a Fleet oriented computer manual for ASW operations using the Radio Shack TRS-80-PC-2 (Sharp PC-1500A) Programmable Calculator.

Summary: An operating manual for fleet use of the newly adopted Sharp PC-1500A handheld computer has been written for the Fleet Mission Program Library.

Publication: R. H. Shudde, "Fleet Mission Program Library Operating Instructions for the Sharp PC-1500A Computer", NTSA-FPL40-7, September 1984.

Title: Soviet Analytical Modelling of Air-Ground Combat

Investigator: J. G. Taylor, Professor of Operations Research

Sponsor: Headquarters, Foreign Technology Division/TQFO, USAF Systems Command

Objective: To investigate the nature and estimate the analytical form of Soviet research models of large-scale air-ground combat.

Summary: Soviet analytical approaches to the modelling of air-ground combat were investigated by examining Soviet open-literature sources (primarily such writings of the Soviet General Staff and associated scientific workers in the original Russian). Based on such literature intelligence (LITINT), the probable nature of such models was conjectured and related to Soviet thought on automation in troop control.

Publications: J. G. Taylor, "A Preliminary Examination of Soviet Analytical Modelling of Air-Ground Combat," NPS Letter Report, September 1984 (77 pages).

Conference J. G. Taylor, "Soviet Cybernetics and Troop/Force Control," SAI/FTD Seminar on Soviet Systems Science, Cybernetics, and Troop Control, Denver, CO, 26 January 1984.

J. G. Taylor, "Systems Theory and Combat Modelling," 52nd MORS, Fort Leavenworth, KS, 7 June 1984.

Thesis Directed: J. J. Manzo and J. M. Hughes, "A Surrogate for Soviet Division Level Automated Troop Control Systems," Master's Thesis, June 1984.

Title: Conceptual Basis for Soviet C<sup>3</sup>

Investigator: J. G. Taylor, Professor of Operations Research

Sponsor: C<sup>3</sup> CM Joint Test Force

Objective: To develop the conceptual basis for Soviet command, control, and communications (C<sup>3</sup>), its implementation, and susceptibility to counter measures. The first phase of this work was to briefly study and document the nature and content of the Soviet theory of command and control.

Summary: The major features of the Soviet theory of troop control were delineated as a result of a careful examination of the Soviet open literature (primarily in the original Russian). We tried to investigate the Soviet perspective on troop control by examining the appropriate Soviet thought in the original Russian language and then explaining it to an American audience in terms comprehensible to Americans.

The major finding of this research was that (in contrast to the American situation) there is a comprehensive and well-thought-out Soviet theory of troop control, which guides both the Soviet practice of troop control and also future Soviet hardware developments. This theory of troop control is a major component of Soviet military strategy and (together with automation of troop control) forms the basis for the third (cybernetic) phase of what the Soviets call the revolution in military affairs.

Publications: J. G. Taylor, "Initial Concept of Soviet C<sup>2</sup>," NPS Letter Report, December 1984 (167 pages).

Conference Presentations: J. G. Taylor, "Some Selected Topics in the Soviet Theory of Troop/Force Control," SAMOA Conference, Warrenton, VA, 15 December 1983.

J. G. Taylor, "Interrelationship of Theory and Practice (A Soviet View)," Workshop on the Role of Military Science and Operations Research in Defense Planning and Operational Art, Monterey, CA, 24 May 1984.

J. G. Taylor, "Soviet Military Operations Research,  
Systems Theory, Cybernetics, and Troop/Force Control:  
How the Soviets Plan to Win the Third World War,"  
Seminar in Military Operations Research, U. S. Army  
Combined Arms Operations Research Activity, Ft  
Leavenworth, KS, 8 June 1984.

Title: Research in Tactical Analysis

Investigators: A. R. Washburn, Professor of Operations Research  
J. N. Eagle, Assoc. Professor of Operations Research  
R. N. Forrest, Professor of Operations Research  
R. H. Shudde, Assoc. Professor of Operations Research  
B. O. Shubert, Assoc. Professor of Operations Research

Sponsor: Office of Naval Research

Objective: To examine the set of navigation programs in the fleet Mission Program Library (FMPL) and integrate them into a coherent program for the Sharp PC-1500A handheld computer.

Summary: An operating system for the Sharp PC-1500A was designed and programmed. Three FMPL navigation Programs were written for the PC-1500A using the operating systems.

Publication: R. H. Shudde, "Some Sharp PC-1500A Computer Navigation Programs for the Fleet Mission Program Library", NPS-84-018, September 1984

Title: Reliability Evaluation of Binary Systems

Investigator: R. K. Wood, Assistant Professor of Operations Research

Sponsor: National Science Foundation

Objective: To develop and implement new techniques for evaluating the reliability of binary systems represented as networks and fault-trees.

Summary: Special state-space partitioning techniques together with topological reduction and decomposition schemes have been developed for computing K-terminal reliability in undirected networks. A general framework has been devised from which all partitioning algorithms may be viewed and evaluated making possible valid comparisons of different techniques. A prototype partitioning and decomposition algorithm has been implemented for the evaluation of fault-trees. The algorithm employs recursive partitioning and a variety of reduction and decomposition steps to minimize the enumeration required making it significantly more efficient than techniques based on cut-set enumeration. The output of the algorithm is either the probability of the top event of the fault-tree or a valid set of Pascal statements for repeated evaluation of the fault-tree with varied inputs.

Publications: R. K. Wood, "A Factoring Algorithm Using Polygon-to-Chain Reductions for Computing K-Terminal Network Reliability," Networks, (forthcoming).

R. K. Wood, "Factoring Algorithms for Computing K-Terminal Network Reliability," submitted to IEEE Transactions on Reliability.

Thesis Directed: W. T. McCullers III, "Fault-tree Evaluation Through Direct Factoring," to be completed September 1985.

**DEPARTMENT  
OF  
NATIONAL SECURITY AFFAIRS**

## DEPARTMENT OF NATIONAL SECURITY AFFAIRS

Research concerns, interests, and topics of the Department of National Security Affairs conform generally to its curricula.

These range from (1) Geographical Area Security Studies embracing Africa, East-, South-, and Southeast Asia, Middle East, Europe, Pacific Basin, and USSR, to (2) Functional Specialty Studies, comprising Intelligence, International Organizations and Negotiations, and Strategic Planning. Accordingly, the research endeavors span a broad spectrum, and focus on security interests of the United States in relation to other major international economic and political polities. Special emphasis is accorded the role of the military linking world-wide cultural, economic, historical, legal, political, and technological factors which shape the global capabilities, interests, and security policies of the United States. The broad fields of research are:

### (a) Regional Politico-Military Analysis

These analyses focus on world areas of vital interest to the United States, specifically Africa, Asia, Europe and the Middle East/Southwest Asia.

African research results include: a monograph, The United States and South Africa; a major report, Nimiyer Under Seige; three book chapters, "The Impact of Grenada on American Standing in the Third World," in Valenta, forthcoming; "Observations on the Zimbabwe Success," in Clark, The United States and the Third World;" "Strategic Responses to Escalating Conflict in Mozambique and Zimbabwe," in Taylor, Strategic Responses to Conflict in the 1980s; three articles, "On Afrocommunism," in Problems of Communism; "U.S. Policy in Southern Africa," in Current History; and "Whither Zimbabwe?" in CSIS Africa Notes.

Professor Clough briefed the U.S. Ambassador-designate to Zimbabwe for the State Department, lectured at the Air War College, National Defense University, Foreign Service Institute, John F. Kennedy Center at Fort Bragg, and took part in a CIA conference on South Africa. Concomitantly, Clough appeared on the MacNeil-Lehrer Report, KQED's national radio show on foreign affairs, ten interviews broadcast by the Voice of America, and was quoted in Wall Street Journal and Christian Science Monitor.

Adjunct Professor Winterford is engaged in preliminary research on "Foreign Investment in African Development," concerned with national receptivity to foreign investment as an alternative to parastatal organizations.

(b) Asian research was prolific. From Professor Jencks flowed a co-edited book, Chinese Defence Policy in the Eighties, by Macmillan (England) 1984 and University of Indiana Press 1985; one article, "Peoples War Under Modern Conditions: Wishful Thinking, National Suicide, or Effective Deterrent?" in The China Quarterly, June 1984; and a reprinted (from Conflict) article, with Don Daniel, "Soviet Military Confrontation with China:

Options for the USSR, the PRC, and the USA" in The Journal of East Asian Affairs. A consultant for SRI International in Menlo Park, Professor Jencks also reviewed two articles, one each in Asian Survey (Winter 1984) and Pacific Affairs (Spring 1984).

Professor Olsen contributed thirteen articles published in journals and newspapers; wrote U.S.-Japan Strategic Reciprocity, Hoover Institution Press 1984, and co-authored Arms Production & Trade in Developing Countries, Lexington Books 1984, Japan's Foreign Economic Relations in the 1980s, West-view 1984, and Korean Unification: New Perspectives and Approaches. The articles are; "Nihon No Kairyō Kikyo No Tsuyomi," in SEKAI SHUHO, Japan, October 1983; "Is a Kim Dynasty in North Korea Best for Seoul," in Asian Wall Street Journal, October 1983; "Confucious, Mao, Castro Inspire Kim's North Korea," in Asian Wall Street Journal, February 1984; "Juhan Migun wi jung chi jugi yong ui nam jum," in Dong-A Ilbo, May 1984; "Crabs, Birds, & U.S. Strategic Priorities in the Far East," in WORLDVIEW, November 1983; "Mi-Il Mi-Han i won wha boda Har-mi-Il Samgak hyubryug baram jig," in HANOOK ILBO, November 1983; "The Evolution of the ROK's Foreign Policy," in Washington Quarterly, Winter 1983; The Politics of Adversary Relations: the U.S., Japan & North Korea, in Korean Observer, Winter 1983; "Treating South Korea as the 'New Japan,'" in Christian Science Monitor, May 21, 1984; "The Catch-22's of Korean Unification," in Asian Wall Street Journal, June 1-2, 1984; "Viking Fritz: The Invisible Ethnic," in Christian Science Monitor, September 28, 1984; "The Japanese Rediscover Korea," in Asian Wall Street Journal, October 11, 1984; and "Amerika No Saiko Chisei Kunin Ga Kinpaku No Nichi-Bei Kankei Ni Chidai Hatsugen," in SHUKAN BUNSHU, January 12, 1984. Professor Olsen was named one of "America's Nine Leading Intellectuals" who work on Japanese issues.

Adjunct Professor Jurika wrote fourteen prepublication book reviews for the San Diego Union and the Copley Press Service. They embraced espionage, counterespionage, intelligence, codes and ciphers, and national security. Among the major books were: Wolf, The Japanese Conspiracy, Empire Books; Cruickshank, SOE in the Far East, Oxford; Suvorov, Inside Soviet Military Intelligence, Macmillan; Golitsyn, New Lies for Old, Dodd Mead; Barron, KGB Today, Readers Digest; Deacon, KEMPEI TAI: A History of the Japanese Secret Service, Beaufort; Lewin, The American Magic, Farrar Strauss Giroux; Smith, The Shadow Warriors, Basic Books; and Kahn, Kahn on Codes, Macmillan.

South Asia and Middle East research was undertaken by Professor Magnus, who contributed two published book reviews to The Middle East Journal; wrote "Tribal Marxism: The Soviet Encounter With Afghanistan," in Conflict, October 1983; with Professor Amos an accepted article, "Regional Reactions to CENTCOM: Perceptual and Strategic Dimensions," for Conflict; co-edited IRAN and SAUDI ARABIA: Problems and Possibilities for the U.S. in the Midrange, Strategic Studies Institute; co-edited Gulf Security into the 1980s, Hoover Institution Press; with Professor Amos revised Responding to Crises in Southwest Asia for Westview Press; edited Afghan Alternatives: Issues, Options and Policies, Transaction Books, forthcoming; and contributed chapters in Gulf Security into the 1980s and Afghan Alternatives: Issues, Options and Policies. Also forthcoming is Afghanistan and the USSR: A Twentieth Century Jihad, with E. Naby and Professor Looney for Hoover Institution Press.

(c) European research was also very productive. Professor Yost authored eight articles; "Frankreichs Politik in Tschad und die Herausforderung durch Libyen," in Beitrage zur Konfliktforschung; Fall 1983; "European-American Relations and NATO's Initial Missile Deployments," in Current History, April 1984; "START, INF und europaische Sicherheit," in Europa-Archiv, October 25, 1983; "START, INF and European Security," in The World Today, November 1983; "Die Sorgen der Europaer gegenuber den amerikanischen Planen fur eine Raketenabwehr," in Europa-Archiv, July 25, 1984; "Les inquietudes europeennes face aux systemes de defense anti-missiles: Un point de vue americain," in Politique Etrangere, Summer 1984; and "European Anxieties about Ballistic Missile Defense," in Washington Quarterly, Fall 1984. A Technical Report, Policy Implications of West European Reactions to the March 1983 U.S. Proposals for Ballistic Missile Defense for Pan Heuristics, 1984; a book, Die Zukunft Atomarer Rustungskontrolle in Europa: von SALT zu START und INF, for Bernard und Graefe Verlag, 1984, and a chapter in Huber and Avenhaus, eds. Quantitative Assessment in Arms Control, Plenum, 1984, caps Professor Yost's contributions. Research for two other books was completed during the year.

Adjunct Professor Zelikow published an article, "Force Without War. 1975-1982," in Journal of Strategic Studies, and his "Visions of the Future War in Europe" will appear in the report of conference proceedings, forthcoming.

Professor Stolfi developed a general equation which defines the political power of a state and integrates the crucial elements on which political power and military balance are based. He, with General von Mellenthin, German Army (Retired), planned, organized and wargamed a 5-day exercise at First Marine Division, Camp Pendleton, California to increase the mobility of Marine Corps field forces in mobile war beyond the beachhead. A 23-minute film, and another longer one, have been completed, and an article on the war game is ready for submission to Corps Gazette. Professor Stolfi (with R. McEachin) also produced a Confidential Technical Report, "A-10/GAU-8 Low Angle Firings Against Simulated Soviet Tanks in Tactical Formations," for the J.S. Air Force. With General Mellenthin, Professor Stolfi published NATO UNDER ATTACK: Why the Western Alliance Can Fight Outnumbered and Win in Europe Without Nuclear Weapons, Duke University Press, 1984.

(d) Following an important August conference at NPS on Soviet-Cuban strategy in the Caribbean, Professor Valenta produced an article, "Leninism in Grenada," in Problems of Communism, July-August 1984; co-edited a Conference Report, Soviet/Cuban Strategy in the Third World After Grenada: Toward Prevention of Future Grenadas, The Wilson Center, 1984; and wrote a book, GRENADA, USSR AND CUBA: Crisis, Intervention and Impact, Westview 1985. Earlier he published "Revolutionary Change, Soviet Intervention, and Normalization: in East-Central Europe," in Comparative Politics, January 1984; with others, "Central America and the Caribbean International Politics," in the AEI FOREIGN POLICY DEFENSE REVIEW, February 1984; and an essay review of "The Grand Strategy of the Soviet Union," in The Wilson Quarterly, Spring 1984. Professor Valenta wrote a chapter, "Soviet Arms and Options in Afghanistan," in Magnus ed. Afghan Alternatives; with F. Shaheen another chapter, "Soviet Views on Central America," in Cirincione, ed. Central America and the Western Alliance, 1985; a chapter, "Structure and Crisis of the Soviet Union's East European Security System," in Kaltefleiter and Schumaker, eds., Conflicts,

Options, Strategies, IPS, Kiel, West Germany 1984; and another chapter, "Soviet Intervention in Eastern Europe," in Rakomka, Communism in Eastern Europe, 1984. To cap an impressive year, Professor Valenta wrote, "Why Gromyko Saw Reagan and Mondale," in The New York Times, October 5, 1984.

(e) The functional specialties also provided exceptional research and publications, much of it part of a continuing search for superpower strategic stabilization, strategic deception, international strategic and economic studies, and changing parameters of naval warfare. Professor Daniel's article, "Antisubmarine Warfare in the Nuclear Age," appeared in ORBIS, Fall 1984, and his book, Antisubmarine Warfare and Superpower Strategic Stability, Macmillan, London, is forthcoming. With Professor Jencks, he wrote, "Soviet Military Confrontation with China: Options for the USSR, the PRC, and the USA," in Journal of East Asian Affairs. A monograph on the U.S. and Soviet Navies in the Pacific is forthcoming, soon.

Adjunct Research Professor Herbig, engaged in massive research on strategic deception, wrote "Operation WEDLOCK: American Strategic Deception of the Japanese in the North Pacific, 1942-1945," in Intelligence: Policy and Process, Turnstall, Mauser and Keagle, eds., Westview 1985. With Professor Daniel, a chapter, "Deception in Military Affairs: Propositions for Historical Analysis," in Clio Goes Spying: Eight Essays in the History of Intelligence, Agrell and Huldt, eds.

Professor Looney, engaged in forecasting major economic aggregates in the Jamaican economic model for the Inter-American Development Bank, completed a book, Stabilization Efforts in an Open Economy: The Jamaican Experience, Duke University Press, forthcoming. From the same press Professor Looney has Economic Policymaking in Mexico: Factors Underlying the 1982 Crisis, forthcoming in April 1985. Among his many articles accepted for publication are: "Inflation and Oil Based Development: Failure of the Monetariat Model in Saudi Arabia," in Rivista Internazionale Di Scienze Economiche e Commerciali; "The Impact of Oil Revenues on the Pre-Revolutionary Iranian Economy," in Middle Eastern Studies; "The Mexican Oil Syndrome," in OPEC Review; and "Defense Expenditures and Economic Growth in Developing Countries: A Reply," in Armed Forces and Society. He is engaged in editing his chapter in Foresight Capability and Political Constraints on Mexico, Duke University Press, forthcoming. Professor Looney also reviewed Adda Guecioueur, "The Problems of Arab Economic Development and Integration," in Journal of Energy and Development, October 1984; and Sepehr Zabih, "Iran Since the Revolution," in Third World Quarterly, forthcoming. His deep research interests continue apace in the economics of Mexico and other Latin American countries, major recipients of IADB funds.

(f) Professor Clough organized and chaired a conference on "Implications for East-West Relations of Recent Developments in Angola, Ethiopia, Mozambique and Zaire" at NPS; presented a paper in Moscow at a US-USSR conference on Africa; and chaired a Current Issues Panel at the African Studies Association Panel.

Professor Valenta arranged and chaired a conference on "Soviet-Cuban Strategy in the Third World After Grenada: Toward Preventing Future Grenadas" at NPS; presented a paper at that conference, "Leninism in Grenada;" contributed "Grenada's Revolution," at the Wilson Center conference

on Grenada; read his paper, "Soviet Strategy in the Caribbean Basin," at the Kennan Institute of Advanced Russian Studies, and "Crises at the Soviet Periphery: U.S. Preventive Diplomacy," at the Wilson Center; and offered "Soviet Views on Central America," at the Carnegie Endowment.

Professor Daniel attended the FPRI Conference on the Changing Parameters of Naval Warfare, presenting "Antisubmarine Warfare in the Nuclear Age," attended the Naval War College Conference on Politico-Military Affairs, the IISS meeting at Avignon, and the Air force Academy Conference on Intelligence and Politics where he presented "Military Deception."

Adjunct Professor Herbig presented "Operation Wedlock," and "Battle of Wits: Military Strategic Deception," at the Air Force Academy conference on Intelligence and Politics; briefed an Army special plans group on deception; and visited Japan to interview former IJN officers and military historians regarding their views on U.S. strategic deception. At the Army War College, Professor Stolfi attended a Symposium on the Art of War and presented a paper on "Application of German Command Style in WWII to NATO Today." At the Marine Corps Base, Camp Pendleton, he lectured on "Historical Analogy and Command Style in Modern War."

Professor Olsen was a guest lecturer for two weeks at the Japanese National Defense Academy, and led seminars at the Japanese Defense Agency. He also attended the US-ROK Seoul Conference on Northeast Asian Security; the Association for Asian Studies Conference in Washington; the International Studies Association (ISA) meeting in Atlanta; the US-Asia Institute annual meeting, and the ISA Military Studies Section at the USAF Academy.

In addition to his wide research interests, Professor Magnus is Project Director, Americas for Afghans; and recorded an interview broadcast by Voice of America. He is preparing "Implications of the Iran-Iraq War and Afghanistan as Conflict Models," and working with others on a book, Economic Dependencies in Soviet Expansionist Strategies. Professor Yost has worked in the Pentagon on arms control negotiations in Europe; European reactions to the U.S. Strategic Defense Initiative; and nuclear strategy. He served as rapporteur for two conferences of the European-American Institute for Security Research: "European and American Critical Interests In and Out of NATO," and "West Europe and the Future of Active Defense and Long-Range Offense." During a research trip to Rome, Yost presented "Ballistic Missile Defense and European Security" at the Institute Affari Internazionali to officials of the Italian Foreign and Defense Ministries. Professor Jencks visited the Army Foreign Area Officers (FAO) School at Fort Bragg, and is the liaison for NPS with FAO School, U.S. Consulate General, Hongkong, B.C.C., British Ministry of Defence Chinese Language School (Hongkong), the U.S. Army Western Command, Fort Shafter, HI, and the Defense Language Institute, Monterey.

Finally, NSA faculty are advisers and research assets for the many student theses developed during their year and a half tenure at NPS. Their wide-ranging talent and extensive experience, freely given, are invaluable guides on a wide variety of topics of interest to the armed forces and the nation.

Title: Antisubmarine Warfare and Superpower Strategic Stability

Investigator: D. C. Daniel, Associate Professor of National Security Affairs

Sponsor: International Institute for Strategic Studies

Objective: Investigate whether superpower antisubmarine warfare developments are strategically destabilizing

Summary: The study: (1) proposed a framework for establishing whether or not ASW development would be considered destabilizing; (2) outlined the physical and oceanographic parameters which determine and limit what can be done in ASW; (3) reviewed the open literature on U.S. and Soviet developments in ballistic missile submarines and antisubmarine warfare; and (4) concluded that for the foreseeable future, in the absence of an unpredictable breakthrough, neither superpower would have a destabilizing ASW capability.

Publications: D. C. Daniel, Antisubmarine Warfare and Superpower Strategic Stability (London: Macmillan, forthcoming).

D. C. Daniel, "Antisubmarine Warfare in The Nuclear Age," Orbis (Fall 1984), 527-552.

Conference Presentations: D. C. Daniel, "Antisubmarine Warfare in The Nuclear Age," FPRI Conference on The Changing Parameters of Naval Warfare, Washington, D. C., May 4, 1984.

Title: American Strategic Deception in the Pacific Theatre, 1941-1945

Investigator: K. L. Herbig, Adjunct Research Professor of National Security Affairs

Sponsor: Office of the Secretary of Defense

Objective: This project provides a historical analysis of the American campaign to deceive the Japanese on a strategic level about U.S. intentions in the Pacific during World War II. It is based on original documents not used before, including ULTRA intercepts recently declassified. It seeks to describe American deception goals, programs, and organization, and to evaluate the results of the deception campaign on the war in the Pacific.

Summary: Results from this research so far demonstrate that the U.S. committed more resources and effort to strategic deception against the Japanese than has been credited in histories of World War II to date. The impact of British experience and advice was considerable on the U.S. effort, but tensions between the Allies also persisted and prevented complete cooperation in the deception campaign. The U.S. Joint Chiefs of Staff preferred a decentralized organization for deception which vitiated much of the effectiveness of deception planning before early 1945. Nevertheless, deception can be shown to have had measurable impact on the strategic decisions and developments of the Japanese Imperial General Staff, and thus to have helped the U.S. win the Pacific war.

Publications: "Operation WEDLOCK: American Strategic Deception of the Japanese in the North Pacific, 1942-1945" in Intelligence: Policy and Process edited by David Turnstall, Al Mauser, and James Keagle. Westview Press, 1985, forthcoming.

Conference Presentation: "Operation WEDLOCK" at "Intelligence and Politics: Policy and Process", Air Force Academy, June 5-6, 1984.

Title: Application of German WWII Panzer Command Style to Present Day High Intensity War

Investigators: Professor Russel H. S. Stolfi, National Security Affairs, and Major General F. W. von Mellenthin, German Army (Retired)

Sponsors:

- (1) Headquarters, U.S. Marine Corps, Washington, DC.
- (2) U.S. Army War College, Carlisle Barracks, PA.
- (3) First Marine Division, Marine Corps Base, Camp Pendleton, CA.

Objective: To present German WWII panzer command style and test its applicability to newly developing mobile warfare concepts, tactics, and organizations in the Marine Corps. The research was part of a continuing program in the Marine Corps to increase the mobility of the field forces in mobile war beyond the force beachhead line.

Summary: After a long period of preparation, General von Mellenthin was invited from South Africa to present at Camp Pendleton, CA, his experiences and views on mobile warfare. The former German General acted as a Marine Amphibious Force commander in a desert map exercise (5-day period, April 1984) and maneuvered the First Marine Division in the style of an experienced panzer leader of WWII. The Marine Corps was able to extract several important points for application to high intensity war in terrain favorable to the employment of armor, e.g., Southwest Asia and Central Europe.

Publications:

- (1) A film (23 minutes) was produced by the Marine Corps on the war game.
- (2) A longer film is in the process of being edited on the same war game for more general distribution in the Marine Corps after appropriate review and approval.
- (3) An article on the war game is in progress for submission to the Corps Gazette (or, alternatively the Military Review).

Conference Presentation: In the period 26-30 March 1984, Professor Stolfi and General von Mellenthin attended the U.S. Army War College, Symposium on the Art of War, as participants

and presented papers on German military operations against the Soviets in 1942-1943 (Mellenthin) and the application of those experiences today (Stolfi presentation on the recent publication Nato Under Attack (Durham, NC: Duke University Press, 1984)).

Thesis Directed: Closely related to the research is the following thesis directed by Professor Stolfi: Captains William Troy and Thomas Turner, USA, Command and Control of Ranger Forces in a European Theater, NPS Masters Thesis (Monterey, CA, December 1984).

Title: Soviet-Cuban Strategy in the Third World after Grenada: Toward Prevention of Future Grenadas

Investigator: Jiri Valenta, Associate Professor and Coordinator of Soviet and East European Studies, Department of National Security Affairs

Sponsors: Office of the Secretary of Defense, Deputy Under-secretary of Defense for Policy--Public Diplomacy; Kennan Institute for Advanced Russian Studies of the Wilson Center, Smithsonian Institution; and National Strategy Information Center

Objective: To examine Soviet and Cuban strategy in the Caribbean Basin following the Grenada operation of October 1983 and to assess U. S. options in dealing with Soviet-Cuban strategy

Summary: An intensive effort to organize a first-class conference of leading academics and key policymakers to deal with Soviet and Cuban strategy was completed, following publication of an influential essay on Grenada by principal investigator. The conferees analyzed the impact of Grenada's revolution on Soviet strategy in the Caribbean, but also in Angola, Ethiopia and other strategic parts of the Third World by utilizing documents captured in Grenada. Utilizing guidelines set forth by the investigator, the conferees examined in bipartisan fashion, U. S. options in terms of the opportunities and obstacles to U. S. policy precipitated by the intervention. The investigator wrote a summary and recommendations as part of a brief but influential conference report for use by U. S. policymakers.

Publications:

J. Valenta, "Leninism in Grenada," Problems of Communism, July-August, 1984, pp. 1-23.

J. Valenta, Grenada, USSR and Cuba: Crisis, Intervention and Impact (Boulder, CO: Westview Press, March 1985) (J. Valenta co-editor).

J. Valenta, Conference Report Soviet/Cuban Strategy in the Third World After Grenada: Toward Prevention of Future Grenadas (Washington, D. C.: The Wilson Center, 1984).

Conference Presentations: J. Valenta, "Leninism in Grenada," Conference on Soviet/Cuban Strategy after Grenada, NPS, August 15-18, 1984.

J. Valenta, "Grenada's Revolution," Wilson Center Conference on Grenada, March 2, 1984.

Thesis Directed: Lt. Fred Shaheen, USN, "Soviet/Cuban Influence in the Caribbean Basin: Strategy, Maritime and Regional Threat to U. S. Security."

Title: French Security Policies

Investigator: D. S. Yost, Associate Professor of National Security Affairs

Sponsors: Fritz Thyssen Foundation and International Institute for Strategic Studies

Objective: To advance understanding of French policies in several areas, including nuclear weapons programs, interventionary forces, arms control, and European security.

Summary: Research to date has focused on the French strategic studies community, policy-making processes, interventionary capabilities and contingencies in Africa, nuclear weapons targeting, and policies regarding European security. In each of these areas, the existing literature in French and English has been thoroughly reviewed, and numerous interviews with French officials have supplemented and clarified published sources.

Publications: D. S. Yost, France's Deterrent Posture and Security in Europe, Part I: Capabilities and Doctrine Adelphi Paper, London: International Institute for Strategic Studies, forthcoming.

D. S. Yost, France's Deterrent Posture and Security in Europe, Part II: Strategic and Arms Control Implications. London: International Institute for Strategic Studies, forthcoming.

D. S. Yost, France and Conventional Defense in Central Europe, EAI Paper no. 7, Marina del Rey, California: European-American Institute for Security Research, 1984.

**DEPARTMENT  
OF  
PHYSICS**

## DEPARTMENT OF PHYSICS

The Physics Department has made a concerted effort to expand its research activities in acoustics, radiation damage and space physics. New faculty have been hired in all three fields: A. Atchley, S. Baker, S. Gnanalingam, N. Glass and S. Nerney. The recent acquisition of a pulsed electronbeam machine will substantially increase our capabilities for both radiation damage and directed energy research. Dr. Nichols will continue for an additional year in the ONR Underwater Acoustics Chair to assist in expanding our ocean-acoustics research capabilities. Additional personnel to our research staff are: R. Mensch (electrooptic systems), J. Glendening (atmospheric modeling), and J. Lentz (optical propagation).

### ACOUSTICS

Professors J. Sanders and A. Coppens are continuing their investigations of the propagation of acoustic waves in shallow water. Modeling of propagation from a fluid wedge into a fast bottom and within the water has been continued using the method of images. Propagation upslope, downslope, and crossslope in the wedge is being studied. A scale model experimental facility for investigation of propagation along regularly sloping bottoms has been constructed, and another facility more suitable for irregular profiled bottoms is being implemented.

Professor O. Wilson is engaged in a Navysponsored bookwriting project. The book, "Introduction to the Theory and Design of Transducers for Underwater Sound", is to be published in the Fall of 1985. Professor Wilson has begun collaboration with Professor Garrett on developing techniques for hydrophone performance monitoring.

Professor Steven Garrett is engaged in several conventional underwater acoustical projects involving transducers: design and testing of fiber optic gradient hydrophones in collaboration with Dr. E. F. Carome; design of an automated sonar hydrophone testing facility to improve the shading of arrays; and, reciprocity calibration in unusual geometries. This latter project, using resonant calibrators in gases, was begun with LCDR C. Burmaster and is being continued in water using both rigid and compliant slowwave resonators.

Additionally, Professor Garrett has moved into the space

environment. Along with CDR Chuck Stehle and Lt. Scott Palmer, he has a "getaway special" project on the space shuttle to measure the vibroacoustic environment in the cargo bay. An acoustic refrigeration scheme for cooling spaceborne detectors is also under development.

Adjunct Professor Steven Baker has initiated a program in sediment acoustics. Projects slated for the coming year include the development of a new resonance method for determining the complex propagation constant of sound in a fluid saturated porous solid and the first direct measurements of the complex effective fluid mass density of an oscillating, nearly incompressible fluid contained in a porous solid.

#### SURFACE PHYSICS

Professor Don Harrison uses computer simulations to study atom ejection effects produced by the ion bombardment of clean and chemically reacted metal surfaces. The results can be directly compared to data from Secondary Ion Mass Spectrometry (SIMS) and Fast Atom Bombardment (FAB) experiments. The project is supported by a Special Opportunity Grant from the Office of Naval Research.

Recently published investigations studied the effect of electronic energy losses on atom ejection and nonlinear effects in collision cascades. Work in progress on low (less than 200 eV) energy ion bombardments anticipates the development of simulations of reactive ion etching.

#### CONDENSED MATTER

Professor N. Glass is engaged in theoretical research on surface excitations and their interaction with surface roughness, especially periodic roughness. Work is being carried out on resonant coupling of bulk light waves to surface polaritons on metal bigratings and on surface-polariton-enhanced Smith-Purcell radiation from an electron beam near a bigrating.

#### LASER AND PLASMA PHYSICS

Professor Fred Schwirzke is continuing his work on the investigation of the breakdown and unipolar arcing which occur when a laser beam interacts with a target surface. Unipolar arcing is an electrical plasma-surface interaction process which leads to crater formation, usually called laserpitting. At low irradiance, this is

the only observable type of lasertarget interaction. With support from Naval Research Laboratory, measurements of laserinduced unipolar arcing have been carried out on a variety of materials. Recently, an electron beam/flash xray machine has been acquired. Professor Schwirzke plans to use the facility for an experimental research program on pulsed power. The electron beam will be used to produce and sustain plasma and radiation conditions in argon which are appropriate for lasing in the XUV or soft xray spectral range. Pulse-power technology is becoming increasingly important in many energy and defense applications. MV voltage pulses can be induced when a conducting switch is rapidly opened in an inductive system. A microscopic model and scaling laws for a plasma opening switch have been proposed and will be tested on the new machine.

#### ENVIRONMENTAL PHYSICS

The Environmental Physics Group continues as a joint project of the Physics and Meteorology Departments, directed by Professors Kenneth Davidson, Gordon Schacher, and Will Shaw. Torben Mikkelsen from RISO National Laboratory, Denmark, and Jack Glendenning from Washington State University have joined the group to work on its dispersion projects.

The group continues basic and applied research in atmospheric physics and meterology, concentrating its efforts on modeling for overwater and coastal regions. Current major programs are properties of the marginal ice zone and diffusion in complex terrain. In both programs, the modeling work is supported by extensive field measurements. The following description concentrates on the diffusion work; descriptions of other work appear in the Meteorology Department report.

The data collection phase of the project to characterize Space Shuttle exhaust gas diffusion has been completed. A three laboratory joint effort, with NPS, RISO National Laboratory, and Iowa State University as participants, to model flow and diffusion at Vandenberg has begun. The program will continue for three years. The output of the program will be hand books of dispersion estimation procedures, hazard climatologies and a puff model which is parameterized for the Vandenberg complex terrain.

The characteristics of the turbulence structure on a steep hillside has been investigated with two arrays of three sensors. Work is underway to determine spatial and temporal coherence, the

dependence of the turbulence intensity on local flow conditions, and the spectral distribution. The results will be compared to similar data from a flat terrain site.

The overwater diffusion work has culminated in the production of threatcorridor displays that allow one to easily separate the effects of meander and relative diffusion.

#### LINEAR ELECTRON ACCELERATION

At the LINAC, experimentation has continued on Cerenkov radiation, and new work on radiation effects has begun. The Cerenkov radiation produced by the LINAC electron beam traveling in air reflects the spatial structure of the electron beam. In principle, microwave observations give information about the gross structure of the beam while higher frequency measurements will give information about a single charge bunch. A paper suggesting Cerenkov radiation as an electron beam diagnostic has been published. Experiments and calculations of microwave Cerenkov radiation are continuing under the sponsorship of NAVSEA and DARPA. Calculations of the time development of Cerenkov radiation are underway.

Dr. Maruyama has returned to his permanent duty station at NBS and Professor Buskirk has returned from Los Alamos where he worked with high current electron beams.

Professor Dimiduk has begun studies of the behavior of the semiconductor materials CdTe and HgCdTe electron irradiation. The degradation of various composition of GaAs<sub>1-x</sub>P<sub>x</sub> LEDs under electron irradiation has been measured. Damage studies are continuing with IrGaAsP LEDs and IrGaAs detectors for 1.3 micron fiberoptic communications. Work has started on irradiating SOI transistors.

#### ATOMIC PHYSICS

Professor Raymond Kelly has continued to operate the Spectroscopic Data Center with support from NASA and NBS. His compilation of spectroscopic data has continued to be an important source of data for researchers everywhere and is constantly used in the areas of high-temperature plasmas and solar physics.

A compilation of vacuum ultraviolet (VUV) spectral lines below 2000 Å for all elements between hydrogen and argon was published in 1982. A new work covering the elements from potassium to krypton is

to be published in 1986.

Current plans are to extend the VUV spectral line compilation to elements beyond krypton.

#### EXPLOSIVE CHEMISTRY

Professors Richard Reinhardt and Gilbert Kinney have continued their work, sponsored by the Naval Weapons Center and the Naval Surface Weapons Center, on the subject of chemical equilibria and overpressures resulting from the internal explosions of conventional and explosive fuels in the presence of reactive metals.

Calculations were performed for the temperature, pressure, and product yield expected for the adiabatic internal explosion of aluminum loaded PBX material in air. Calculations were begun for the related problems for magnesium plus aluminum. This is a long-term project which is expected to continue.

#### ELECTRO-OPTICS

Professor A. W. Cooper and E. A. Milne and students are engaged in computer modelling of performance of infrared systems in the marine atmospheric environment. The major thrust of the program is the evaluation of effectiveness of offboard countermeasure devices and tactics by computer simulation of encounters between incoming missiles and a ship protected by such devices. The Stochastic Infrared Engagement Model (SIREM) simulation code developed at Naval Research Laboratory has been modified and installed in the Wargame Laboratory at NPS. Provision has been made for the inclusion of results of LOWTRAN6 propagation code already installed in interactive form on the IBM 3033. Further improvement in the code and evaluation of system designs and tactics in a variety of appropriate scenarios are in progress.

In conjunction with this program, Professors A. Cooper, E. Crittenden, and G. Rodeback are engaged in development of a light, low-cost, expendable laser altimeter for possible incorporation in developmental offboard countermeasure devices for shipboard use. This involves design and prototype construction and testing. Three thesis students are currently engaged in this program.

Professors A. Cooper, E. Crittenden, and Mr. W. Lentz have been progressing in the establishment of an Infrared Surveillance and

Target Designation study facility, based on the Advanced Development Model of the AN/SAR-8 IRSTD. This system is currently undergoing refurbishment and modification, and the data acquisition and recording system being assembled. The scanner will be mounted in a rooftop location with access to shoreline, sea horizon, and airport runway views. This system is then to be applied to the development of a statistical data base of background and target scenes under instrumented conditions, and will be used as a test bed for technology evaluation and the development and testing of algorithms for data processing, clutter rejection and range estimation.

A computer program has been written by Milne for the IBM-PC that can be used to calculate the reflection coefficients for reflection from multilayered coatings on a dielectric or conducting substrate. This program is being adapted to layers of non-isotropic and non-homogenous media. Another computer program under development is for the calculation of spot size due to atmospheric turbulence, spherical aberration, and diffraction.

Title: Microwave Cerenkov Radiation

Investigator: F. R. Buskirk, Professor of Physics and  
J. N. Neighbours, Professor of Physics

Sponsor: Naval Sea Systems Command

Objective: To develop quantitative understanding of  
the microwave radiation from a periodic  
charged particle beam.

Summary: Microwave radiation in both x and k band  
have been detected when the NPS linac beam  
is allowed to propagate in air. This  
radiation has been identified as resulting  
from coherent Cerenkov radiation occurring  
as a result of collective radiation by each  
of the electron bunches in the linac beam.  
A theory of the effect has been developed  
for the radiated power and current research  
efforts are directed towards testing its  
range of validity in the far field. The  
efforts of charge bunch structure are also  
under investigation.

Publications: J. R. Neighbours, F. R. Buskirk, and A.  
Saglam, "Cerenkov Radiation from a Finite  
Gas Cell," Physical Review A. 29 3246-3252  
(June 1984)

F. R. Buskirk and J. R. Neighbours, "Time  
Development of Cerenkov Radiation," NPS  
Technical Report, NPS-61-84-006.

Thesis Directed: M. Vujaklija, "Cerenkov Radiation from  
Periodic Electron Bunches for Finite  
Emission Length in Air," Master's Thesis,  
December 1984.

Title: Establishment of Infra-Red Search Track Facility

Investigators: A. W. Cooper, Professor of Physics

Sponsor: Naval Electronic Systems Command

Objective: To receive, refurbish, and mount the Advance Demonstration Model of the AN/SAR8 Infra-Red Search and Target Designation system on an improved rooftop site at NPS Monterey, to establish a documentation center relating to IRST technology, and to establish a continuing program of research including measurement of sky, sea and land backgrounds leading to the development of a statistical data base, and the use of these data for development and evaluation of algorithms for background suppression, classification and range estimation.

Summary: During the reporting period August through September 1984 the work carried out was concentrated on the site preparations to receive the IRST at Monterey. Two visits were made to evaluate the equipment condition and requirements. The mounting site on Spanagel Hall was selected and space allocation secured. Location and acquisition of documentation was begun, record-keeping equipment was ordered and organization of the documentation center started.

Title: Infra-Red Decoy Modeling and Technology

Investigators: A. W. Cooper, Professor of Physics, E. C. Crittenden Jr., Emeritus Professor of Physics, and G. W. Rodeback, Associate Professor of Physics.

Sponsor: Naval Electronic Systems Command

Objective: To provide technical support to the NATO SEA GNAT program, specifically a) by development of a small light disposable laser altimeter, and b) by undertaking computer simulation modeling studies of IR decoy effectiveness.

Summary: Following a preliminary theoretical analysis which indicated conceptual feasibility, an initial experimental investigation was undertaken using laboratory, non fieldable, equipment. This established possible system parameters and permitted a trade-off analysis of component requirements. Material was purchased and two prototype devices designed and constructed. Computer graphics terminal equipment with appropriate software was selected and ordered to make the graphics capability of the IBM 3033 available interactively at a remote location. The DMAD simulation program tape was received from naval Research Laboratory, and was converted for operation on the VAX-11/780 computer in the Warlab secure computing facility.

Thesis Directed: J. W. Wilson, "Computer Modeling of IR Encounters and Countermeasure Effectiveness," Master's Thesis, December 1984.

Title: Laser Induced Modification of Reflectivity of Optical Materials

Investigators: A. W. Cooper, Professor of Physics

Sponsor: None

Objective: To observe and measure the changes both temporary and permanent produced in the reflectivity and absorptivity of optical detector materials as a consequence of irradiation with moderate to high power laser radiation.

Summary: Measurements have been made of the time resolved reflectivity of extrinsic silicon at helium/neon and argon ion laser wavelengths during irradiation with high power radiation at 1.06 micrometers wavelength from the NPS Neodymium; glass laser system. Measurements were made as a function of input power. Temporary increase in reflectivity was observed in the range 0.46 to 1.05 J/cm<sup>2</sup>. A threshold for permanent damage with decrease in specular reflection was found at 1.05 J/cm<sup>2</sup>. Measurements of power absorption versus angle at 2.8 micrometers and .5 watts cw were made using the NPS HF/DF laser.

Theses Directed: G. D. Johnson and E. L. Chenoweth,  
"Time-Resolved Reflectivity Measurement of  
Extrinsic Silicon During Pulsed Laser  
Irradiation," Master's Thesis, June 1984.  
  
E. Garcia, "Operating Characteristics,  
Absorptivity/Reflectivity Measurements, and  
Pulse System Design of the NPS Hydrogen  
Fluoride/Deuterium Fluoride Laser,"  
Master's Thesis, December 1984.

Title: Pumping Efficiency Evaluation and Improvement in Nd:YAG Laser

Investigators: A. W. Cooper, Professor of Physics

Sponsor: None

Objective: To develop a simply constructed Nd:YAG laser with improved optical pumping capacity.

Summary: Pumping cavities of cylindrical, double elliptical and single elliptical geometry and differing internal surface treatment have been designed, constructed and tested with tungsten halide cw lamps. Comparative fluorescent power measurements have been made. A krypton arc lamp has been obtained to match the absorption bands more closely.

Theses Directed: K. H. Chung, "Construction of a NdYAG laser and Observation of the Output," Master's Thesis, December 1983.  
B. T. Burkett, "Design and Construction of a CW NdYAG Laser Using a Single Elliptical Cavity," Master's Thesis, December 1984.

Title: Finite Amplitude Effects in Cylindrical Cavities

Investigators: A. B. Coppens, Associate Professor of Physics, J. V. Sanders, Associate Professor of Physics, S. W. Yoon, Adjunct Professor of Physics

Sponsor: None

Objective: To investigate the suppression of nonlinear effects of sloshing modes in cylindrical cavities

Summary: The finite amplitude effects of sloshing modes in cylindrical cavities were studied. A perturbation expansion method was applied to the three-dimensional nonlinear acoustic wave equation with dissipative term describing the viscous and thermal energy losses in cylindrical cavities. These theoretical results showed that the nonlinear effects in sloshing modes were strongly suppressed. Currently, the theoretical results are being compared with experimental measurement.

Thesis Directed: S. H. Yum, "Suppression of Finite Amplitude Effects in Sloshing Modes in Cylindrical Cavities," Master's Thesis, December 1983.

Title: A Method of Images Solution for the Sound Field within a Fluid Wedge and in the Underlying Acoustically Fast Substrate

Investigators: A. B. Coppens, Associate Professor of Physics, J. V. Sanders, Associate Professor of Physics, M. Humphries, (former) Adjunct Professor of Mathematics

Sponsor: None

Objective: To obtain a method of predicting the sound field in a shallow water environment which is independent of other methods currently used, and to compare results with other predictive methods and with experimental results from a scaled model experiment.

Summary: For propagation directly up-slope, theoretical predictions were compared to measurements made in a scale-model laboratory facility. The model consisted of water over a 10° sand bottom. Measurements were made at 100 kHz with the sound field sampled vertically at various distances from the shore. Excellent agreement between theory and experiment was obtained

Publication: A. B. Coppens, M. Humphries, and J. V. Sanders, "Propagation of a Sound Beam out of a Fluid Wedge into an Underlying Fluid Substrate of Greater Sound Speed," The Journal of the Acoustical Society of America 76 (5) (1984), 1456.

Conference Presentation: J. V. Sanders and A. B. Coppens, "Propagation of Sound in a Fluid Wedge Overlying a Fast Bottom," 108th Meeting of the Acoustical Society of America, Minneapolis, 8-12 October 1984.

Theses Directed: S. H. Park, "Underwater Acoustic Propagation in the Korea Strait," Master's Thesis, September 1983.  
M. E. Kosnik, "The Implicit Finite-Difference (IFD) Acoustic Model in a Shallow Water Environment," Master's Thesis, June 1984.

R. LeSesne, "Use of the Method of Images to Predict the Field in a Wedge Overlying a Fast Fluid," Master's Thesis, September 1984.

L. E. Jager, "A Computer Program for Solving the Parabolic Equation Using an Implicit Finite-Difference Solution Method Incorporating Exact Interface Conditions," Master's Thesis, September 1983.

C. K. Baek, "The Acoustic Pressure in a Wedge-Shaped Water Layer Overlying a Fast Fluid Bottom," Master's Thesis, March 1984.

Title: Radiation Effects on Infrared Detector Materials

Investigators: K. C. Dimiduk, Adjunct Professor of Physics, and F. R. Buskirk, Professor of Physics

Sponsor: NPS Foundation Research Program

Objective: To study the effects of radiation on semiconductor materials used for infrared detectors and on infrared semiconductor devices.

Summary: HgCdTe, InGaAsP and InGaAs were determined to be important systems for study. Sources for these materials or devices were located and samples were ordered. Various test systems were constructed so that changes in the samples due to irradiation could be determined. In particular, a Beckman 1A spectrophotometer was modified so that changes in the spectral output of LEDs or spectral response of detectors could be monitored. A mount was made for the LINAC so that the LEDs and detectors could be operated during irradiation. A setup was built to make Hall measurements on infrared detector materials at liquid nitrogen temperatures (low temperatures required by the narrow band gap of these materials). Measurements have been made on each of these systems. A mount to keep HgCdTe samples cold during irradiation is under construction. Several InGaAsP LEDs and InGaAs detectors have already been irradiated.

This is a two year project. The work in FY 84 has been primarily equipment construction and preliminary experiments. The work in FY85 will concentrate on data collection and analysis.

Theses Directed:

C. Q. Ness, "Electron Irradiation of Light Emitting Diodes," Master's Thesis, December 1984.

C. P. Bauer, "No Confirmed Title", Master's Thesis, March 1985.

Title: Radiation Effects on Infrared Detector and Emitter Devices and Materials

Investigators: K. C. Dimiduk, Adjunct Professor of Physics

Sponsor: Naval Surface Weapons Center

Objective: To study radiation effects on infrared semiconductor devices, such as the emitters and detectors used for fiber optics.

Summary: Devices that operated at wavelengths of 1.3 microns were chosen as the most important to study because: a) fiber cables have the lowest transmission loss near this wavelength, b) fiber cables operating at 1.3 are less sensitive to radiation than at other wavelengths, and c) the radiation response of devices that operate at 1.3 microns has not been previously studied. Both emitters and detectors for this wavelength were obtained and characterized. They were then irradiated and recharacterized. No changes were observed for the LED emitters at the levels tested. The detectors showed some changes in relative response as a function of wavelength. It was determined that annealing and the dc nature of certain optical measurements were problems in these early experiments. Cheaper, visible LEDs were then used for development of the ability to make ac measurements and to monitor the devices real time under irradiation. These experiments were successful and have been repeated with the infrared detectors. Repeat experiments with the infrared LEDs are planned.

Thesis Directed: C. Q. Ness, "Electron Irradiation of Light Emitting Diodes," Master's Thesis, December 1984.

Title: Radiation Effects on Infrared Detector Materials

Investigators: K. C. Dimiduk, Adjunct Professor of Physics, and F. R. Buskirk, Professor of Physics

Sponsor: NPS Foundation Research Program

Objective: To study the effects of radiation on semiconductor materials used for infrared detectors and on infrared semiconductor devices.

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Thesis Directed: C. Q. Ness, "Electron Irradiation of Light Emitting Diodes," Master's Thesis, December 1984.

Title: Ocean Shallow Sound Channel Effects in the FACT 9H Acoustic Transmission Loss Model

Investigators: C. R. Dunlap, Adjunct Professor of Oceanography and S. W. Yoon, Adjunct Professor of Physics

Sponsor: Naval Ocean Research and Development Activity

Objective: To investigate The acoustic and oceanographic characteristics of shallow sound channels in deep water of the North Pacific and to see how the Fast Asymptotic Coherent Transmission (FACT) 9H model treats the shallow sound channels.

Summary: Propagation in a shallow sound channel of deep water was investigated directly by running the FACT 9H model. Based on a canonical sound velocity profile in deep water of the North Pacific, modified fourteen cases were studied. This investigation showed an existence of an optimum frequency (not always the cutoff frequency) of the propagation in the shallow sound channel when the source and the receiver were located within the shallow sound channel.

Publication: C. R. Dunlap, D. G. Browning, and J. W. Powell, "Shallow Sound Channels in the North Pacific: Causes, Characteristics, and Durations," Journal of the Acoustical Society of America, Supp. 1, Vol. 76 (1984), S84.

Title: Investigation of the Applicability of the Wave-Transform Technique to Propagation Loss Models and Data

Investigators: C. Dunlap, Adjunct Professor of Oceanography and A. B. Coppens, Associate Professor of Physics

Sponsor: NORDA - NAVLEX

Objective: To investigate whether or not the spatial fourier transforms of transmission loss information (pressure and phase as a function of range) can yield information concerning the depth of the source, and if so, how robust the technique is to the presence of range, amplitude, and phase uncertainties in the data. This is a continuing investigation, to be concluded in FY 84-86.

Summary: Work proceeded to refine the analysis of the classical Lloyd's Mirror surface interference sound field by the Wave-Transform technique. Difficulties in the use of the WT technique with the Split-Step Fast Fourier Transform and the Implicit Finite Difference algorithms for solving the parabolic equation were studied, and the causes were isolated. Investigations into the effects of noise and fluctuations in the sound field and the effects of realistic speed of sound profiles and bottoms on the output of the WT program were begun.

Thesis Directed: J. L. Blanchard II, "A Comparison of Two Parabolic Equation Transmission Loss Models for Compatibility with the Wavenumber Technique in the Determination of Source Depth," Master's Thesis, March 1984.

Title: Fiber Optic Gradient Hydrophone (Phase I)

Investigator: S. L. Garrett, Associate Professor of Physics

Sponsor: Naval Electronics Systems Command

Objective: To design a fiber optic gradient hydrophone demonstration unit, based on our previous research, which is self-contained and suitable for testing at sea.

Summary: In this first phase of a two year program, we have constructed sea-worthy, self-contained fiber optic gradient hydrophones using both teflon and epoxy mandrels and both red (0.63 nm) and infrared (0.83 nm) optics. A new instrument system for computer controlled measurement of hydrophone directional characteristic has been successfully tested in the Monterey Bay using the R. V. Acania.

Publications: G. B. Mills, S. L. Garrett, and E. F. Carome, "Fiber Optic Gradient Hydrophone," Proceedings of the International Society of Optical Engineering Vol. 478 (1984), 98-103.

Conference Presentations: G. B. Mills, S. L. Garrett, and E. F. Carome, "Fiber Optic Gradient Hydrophone," Acoust. Soc. Am. Meeting, San Diego, CA, November 1983.

Thesis Directed: G. B. Mills, "Fiber Optic Gradient Hydrophone," Master's Thesis, June 1984.

Title: Evaluation of SONAR Hydrophones by  
Automated Electrical Impedance Measurement  
(Phase I)

Investigator: S. L. Garrett, Associate Professor of  
Physics

Sponsor: Naval Underwater Systems Center

Objective: To construct and test a computer controlled  
impedance measurement apparatus to measure  
the electrical properties of SONAR hydro-  
phones over a range of frequencies and to  
analyze these measurements to determine  
hydrophone performance and failure modes.

Summary: In this initial phase we have successfully  
assembled and programed a computer  
controlled measurement system capable of  
use on a ship or submarine which  
automatically determines equivalent circuit  
parameters along with more traditional  
measurements such as insulation resistance,  
capacitance and dissipation. In Phase II  
we will take this instrument to sea to make  
in situ measurements then remove the  
hydrophones for further testing in our lab.  
At this stage we have recommended to the  
sponsor that future SONAR systems include a  
computer controllable switch/junction box  
so these and other measurements can be made  
routinely with minimal demands on crew time  
and with greater reliability.

Conference  
Presentations:  
L. J. Skowronek, D. V. Conte, O. B. Wilson  
and S. L. Garrett, "Computerized  
Measurement and Analysis of Sonar  
Transducer Equivalent Circuit Parameters,"  
Acoust. Soc. Am. Meeting, San Diego, CA,  
November 1983.

J. D. Johnson, R. E. Self, O. B. Wilson and  
S. L. Garrett, "Computer Immittance  
Measurements", Sonar Transducer Reliability  
Program (STRIP) Meeting, NAVSEA,  
Washington, D. C., 11 September 1984.

Thesis Directed: J. D. Johnson, "Complex Impedance  
Measurement System for Shipboard  
Measurement and Evaluation of Hydrophones",  
Master's Thesis, December 1984.

Title: Reciprocity Calibration in Unconventional Geometries (Phase III)

Investigator: S. L. Garrett, Associate Professor of Physics

Sponsor: Office of Naval Research

Objective: To test extensions of the reciprocity method for absolute calibration of electroacoustic transducers beyond the traditional "free-field" and "coupler" geometries.

Summary: During this period, experiments designed to make precision reciprocity calibrations of acoustic transducers in a plane wave resonator under computer control were completed. This new calibration technique has now been shown to be as accurate and precise as the current method used by the National Bureau of Standards ( $\pm 0.03$  dB). Extensions of this technique to calibration of hydrophones in a waterfilled, compliant walled ("slow-wave") resonator are currently in progress.

Conference Presentations: C. L. Burmaster and S. L. Garrett, "Reciprocity Calibration of Transducers in a Plane-wave Resonator," San Diego, CA, November 1983.

Thesis Directed: C. L. Burmaster, Ph. D. Thesis in Engineering Acoustics, in progress.

Title: Classical Trajectory Simulation Studies of High and Low Energy Particle-Beam Interactions with Solids

Investigators: D. E. Harrison, Jr., Professor of Physics, with M. M. Jakas, Post Doctoral Research Associate (visiting scientist from Centro Atomico Bariloche, Argentina)

Sponsor: Office of Naval Research (Special Research Opportunity Grant: High and Low Energy Particle-Beam Interactions with Solids)

Objectives: Continue study of the effects produced when ions bombard clean and chemically reacted single crystal metal surfaces, to understand mechanisms and to coordinate with experimental investigations. Study damage produced in target surface by bombarding ions. Study fundamental properties of ion bombardment induced cascades in solids.

Summary: Classical trajectory simulations are used to study the cascaded of atoms produced when an ion strikes a target surface. Calculations have been done for combinations of systems using  $\text{Ar}^+$ ,  $\text{O}^+$ ,  $\text{O}_2^+$  and various metal ions in combination with Cu, Ni, W, Mo, Ti, V, and Nb targets. Clean targets, and targets reacted with O and N has been examined. The computed results are presently being compared with experimental data for similar systems obtained at IBM: San Jose, and IBM: Yorktown Heights.

The fundamental mechanism which allows the scattering of 30 keV molecular ions from single crystal W targets has been investigated.

The importance of energy losses by heavy ions to electronic processes has been investigated, and a manuscript is in preparation.

Non-linear collision effects in cascades are now being investigated.

- Publications:
- D. E. Harrison, Jr., "Molecular Dynamics Computer Simulation Study of the Damage Produced in Metal Target Surfaces during Ion Bombardment," In Secondary Ion Mass Spectrometry SIMS IV, 24-30, Edited by A. Benninghoven, J. Okano, R. Shimizu and H. W. Werner, New York: Springer-Verlag, 1984.
- R. P. Webb and D. E. Harrison, Jr., "The Formation of Target Adatoms during the Quenching of an Energetic Ion Induced Cascade in a Crystalline Metal Surface," Radiation Effects Letters Vol. 86(1) (1983), 15-13.
- R. P. Webb and D. E. Harrison, Jr., "A Computer Simulation of High Energy Density Cascades," Nuclear Instruments & Methods 230(B2), (1-3) (1984), 660-665.
- M. M. Jakas and D. E. Harrison, Jr., "Influence of Electronic Energy Losses on Atom Ejection Processes," (Rapid Communication), Phys. Rev. B15, 30(6) (1984), 3573.
- Conference Presentations:
- D. E. Harrison, Jr., "Molecular Dynamics Computer Simulation Study of the Damage Produced in Metal Target Surfaces during Ion Bombardment," (Invited paper) Secondary Ion Mass Spectrometry SIMS IV, Minoo, Japan, 13-19 November 1983.
- D. E. Harrison, Jr., "Computer Simulation of Ion Beam Induced Surface Damage and Mixing," (Invited paper) American Vacuum Society Topical Workshop on Sputtering, San Diego, CA, 6-8 April 1984.
- Theses Directed:
- D. Meyerhoff, "Computer Simulation Studies of Sputtering from Clean Tungsten and Nitrogen Reacted Tungsten and Molybdenum Surfaces," Master's Thesis, December 1983.
- M. G. Mathis, "Computer Simulation Studies of Sputtering and Multimer Formation from Clean and Oxygen Reacted Surfaces of Titanium, Vanadium, and Niobium", Master's Thesis, December 1983.

Title: Field Evaluation of Video Measurements

Investigators: E. A. Milne, Associate Professor of Physics, and E. C. Crittenden Professor of Physics

Sponsor: U. S. Army Electronics Proving Ground

Objective: To design a TV system for measuring the MTF of the atmosphere and compare its performance with the slit scan used at the Naval Postgraduate School in a field test at Fort Huachuca.

Summary: The optics for coupling the TV system to a Celestron-8 Telescope were designed, fabricated and tested. The programs for processing the data from the TV system were developed and tested. A test plan for testing the complete TV system in the field under conditions that included smoke in the optical path was written. The tests were carried out in September at Fort Huachuca and the results of those tests are being analyzed.

Title: Measurement of the Effect of Turbulence on Airborne Optical Projectors

Investigators: E. A. Milne, Associate Professor of Physics, and G. W. Rodeback, Associate Professor of Physics

Sponsor: Pacific Missile Test Center

Objective: To make scintillation measurements between a plane and the ground in order to test the performance of optical equipment.

Summary: A major development for this project was the design and testing of a controller for a GaAs laser transmitter to be used on the aircraft. The design included a feedback circuit for maintaining the output at a constant amplitude. The program was changed to allow simultaneous measurements of the extinction and scintillation. The sponsor obtained an instrument trailer which we converted over for the equipment that we are using for this project. We were prepared to make measurements but the sponsor had problems with their equipment so no measurements were made this year.

Title: X-Ray Cerenkov Radiation

Investigator: J. N. Neighbours, Professor of Physics and  
F. R. Buskirk, Professor of Physics

Sponsor: Naval Foundation Research Program

Objective: To detect soft x-rays generated in solids  
by the Cerenkov mechanism.

Summary: Cerenkov radiation is generated by passage  
of a fast charged particles through a  
medium in which the particle velocity is  
greater than the velocity of the emitted  
radiation. These conditions are not  
generally obtainable in the x-ray region  
except in small wavelength bands in the  
vicinity of an absorption edge.  
Preliminary experiments and calculations  
indicate that a highly collimated beam of  
Cerenkov x-rays are produced when 100 MeV  
electrons from the Linac strike a thin  
target.

Theses Directed: W. J. Farmer, "Cerenkov Radiation in the  
X-Ray Region," Master's Thesis, March 1984  
Y. D. Choi, "Design Consideration for the  
X-Ray Cerenkov Experiment," Master's  
Thesis, December 1984.

Title: Experimental Study of Infrasonic Ambient Ocean Noise

Investigators: R. H. Nichols, Adjunct Professor of Physics

Sponsor: Office of Naval Research

Objective: To investigate relation of infrasonic ocean ambient noise to meteorological and oceanographic factors.

Summary: Data on wind, waves and weather, taken every six hours for three hydrophone locations during a continuous 12-week period, have been obtained from FNOC, analyzed and plotted. Digital ambient noise tape recordings for the first six weeks have been made for the three locations. The noise data are currently being taken off the tapes and printed out for analysis, and for investigation of interrelations with the environmental parameters. Data on coastal surf and on global seismic events, as well as information on Pacific storm tracks, have been received on a monthly basis to aid in the investigation.

Title: Measurement of Acoustic Ambient Noise in the Cargo Bay of the Space Shuttle During Launch

Investigator: R. Panholtzer, Professor of Electrical Engineering, S. L. Garrett, Assoc. Professor of Physics, O. B. Wilson, Professor of Physics, A. E. Fuhs, Dist. Professor of Aeronautics and Space, E. D. Ewing, Professor of Electrical Engineering, Y. S. Shin, Assoc. Professor of Mechanical Engineering, and M. D. Kelleher, Professor of Mechanical Engineering

Sponsor: NPS Foundation Research Program and U.S. Air Force, Space Division

Objective: To measure, record, and interpret the acoustic noise in the Space Shuttle cargo bay during launch using the NASA "Get Away Special" payload program.

Summary: As this is a multidisciplinary effort, the following refers only to work in the acoustics area under Professors Garrett and Wilson which has concentrated on acoustical model analysis of the cargo bay and on instrumentation for the generation and reception of sound. To date we have chosen transducers and amplifiers for this application and created a computerized "shaker table" test facility which can excite these components using a vibration spectrum which closely duplicates the Shuttle's launch environment. Measurements made with the above system indicated that special vibration mounts would have to be constructed to isolate microphones from vibration during lift-off. Those mounts are currently under test. Algorithms for studying cargo bay acoustics resonances using three microphones have been designed, along with a system to excite these resonances remotely prior to launch. These systems will be tested soon.

Theses Directed: C. LD. Stelle, "Microphone Vibration Isolation for Space Shuttle Acoustic Measurements," Master's Thesis, September 1985.

S. E. Palmer, "Automated Cavity Modal  
Analysis for Space Shuttle Acoustic  
Measurements," Master's Thesis, March  
1985.

Title: Internal Explosions in the Presence of Titanium

Investigators: R. A. Reinhardt, Professor of Chemistry, and G. F. Kinney, Distinguished Professor of Chemistry Emeritus

Sponsor: Naval Weapons Center

Objective: Computation of adiabatic temperatures and pressures from the combustion of explosives and fuels in the presence of titanium metal.

Summary: Calculations were conducted according to methods previously used for magnesium and aluminum, in prior years. An important difference for titanium lies in the existence of a large number of condensed-phase oxides. It was assumed that the liquid oxide phase was continuous from pure titanium to titanium dioxide and that its thermodynamic behavior was that of an ideal solution of Ti, TiO, Ti<sub>2</sub>O<sub>3</sub>, Ti<sub>3</sub>O<sub>5</sub>, and TiO<sub>2</sub>. Solid oxides were assumed to be the pure compounds. Other solids present at times were TiN, TiC, and graphite.  
  
As a result of the complexity of the oxide system, the behavior observed with titanium was significantly different from those for magnesium or aluminum. Generally speaking, increasing amounts of titanium caused an increase in temperature but a decrease in pressure owing to the quantity of condensed products. The effect of changing fuels was negligible except for the most oxygen-deficient, where both temperature and pressure were appreciably lowered.

Publication: R. A. Reinhardt, "Computations on Internal Blast from Titanium-Cased Charges in Air," Naval Weapons Center Technical Report, NWTP6544, July 1984.

Title: Validation of a Real-Time Chemical Weapons Hazards Program

Investigators: G. E. Schacher, Professor of Physics and K. L. Davidson, Professor of Meteorology

Sponsor: Naval Environmental Prediction Research Facility

Objective: Evaluate the behavior of a real-time chemical weapons hazard forecasting program for both plumes and burst releases.

Summary: A chemical weapons hazard prediction program has been developed by LCDR James Branum for NEPRF. The program was parameterized using a scheme developed by NPS from overwater tracer data. Model performance validated well when checked against the NPS data. The ability of the model to predict hazard from burst releases was checked with pseudo-instantaneous data sets. The model was found to overpredict puff spread and underpredict downwind hazard distance due to mixing relative diffusion and meander.

Publications: C. E. Skupniewicz and G. E. Schacher, "Assessment of the Performance of an In-Field Gaussian Plume/Puff Model for Overwater Use", NPS Technical Report, NPS-61-85-002, forthcoming.  
C. E. Skupniewicz and G. E. Schacher, "Measured Plume Dispersion Parameters Over Water, Vols. 1 and 2", NPS Technical Report, NPS-61-84-012, September 1984.

Title: Mean Flow and Turbulence in Complex Terrain

Investigators: G. E. Schacher, Professor of Physics and K. L. Davidson, Professor of Meteorology

Sponsor: U. S. Air Force Space Division

Objective: Collect one year of data at Vandenberg AFB and produce a quality assured data archive.

Summary: A data acquisition system was constructed and installed at Vandenberg AFB that collected data from 94 sensors at a 1 sec sampling rate. The system determined means and standard deviations for 15 sec averaging periods. 15 sec, 5 min, 15 min, and 1 hr means and standard deviations were recorded. One full year of data, Aug 1983 to Aug 1984 has been obtained. Quality assurance procedures were developed and utilized to generate the final archived data tapes. Analyses of the diurnal wind cycle and of the characteristics of the mean flow and turbulence are underway. Analyses will continue in order to characterize diffusion in complex terrain.

Publications: G. E. Schacher and T. P. Stanton, "Mean Flow and Turbulence in Complex Terrain, NPS/Vandenberg Measurement System," NPS Technical Report, NPS-61-84-005, March 1984.  
G. E. Schacher, C. E. Skupniewicz and M. Buell, "Mean Conditions and Turbulence at Vandenberg AFB," NPS Technical Report, NPS-61-85-003, forthcoming

Title: Vertical Winds in Complex Terrain

Investigators: G. E. Schacher, Professor of Physics and K.  
L. Davidson, Professor of Meteorology

Sponsor: U. S. Air Force Space Division

Objective: Gather 6 months of vertical wind data at  
Vandenberg AFB to characterize vertical  
diffusion in complex terrain.

Summary: Bivane anemometers have been installed on 4  
of the existing Vandenberg meteorological  
towers, at 54 ft on 052, 102, 101 and 301  
and at the 100 ft level on 101 and 301.  
The four towers are on flat terrain, behind  
a coastal bluff and in very complex  
terrain. 101 and 301 enable us to test the  
height dependence of the turbulence in two  
terrain types. Toward the end of the  
experiment a full vertical array, up to 300  
ft, will be installed on 301. These data  
will complete the development of a data  
base for flow and turbulence in complex  
terrain, adding the needed vertical wind  
data. The equipment has been installed and  
data collection is in its beginning  
stages.

Title: Parameterization of the Riso Puff Model for Complex Coastal Terrain

Investigators: G. E. Schacher, Professor of Physics and S. Larsen, Adjunct Research Professor

Sponsor: NPS Foundation Research Program

Objective: Develop a complex terrain parameterization for the Riso puff model based on data gathered at Vandenberg AFB.

Summary: Data from Vandenberg AFB includes mean flow and turbulence statistics for 12 locations. The locations include several types of terrain and are spread over a wide enough area to enable flow and turbulence fields to be established. These fields will be used to parameterize a site-specific adaptation of the Riso puff model for the base. Characteristic flow regimes have been established and the turbulence fields are being developed.

Thesis Directed: M. Buell, "Mean Flow and Turbulence in Complex Terrain," Master's Thesis, March 1985.

Title: Laser Damage, Unipolar Arcing

Investigator: F. Schwirzke, Professor of Physics

Sponsor: None

Objective: To develop a model of Laser induced unipolar arcing.

Summary: Laser beams interact with surfaces by a variety of thermal, impulse and electrical effects. Unipolar arcing is the primary electrical plasma-surface interaction process once breakdown occurs. Without any external voltage applied, many electrical micro-arcs burn between the surface and the laser heated plasma, driven by local variations of the sheath potential with the surface acting as both the cathode and anode. Unipolar arcing represents the most damaging and non-uniform laser-plasma-surface interaction process since the energy available in the plasma concentrates towards the cathode spots. The onset of arc damage is coincident with the onset of plasma formation. Never was there a plasma evident without attendant unipolar arc craters. At low irradiance there was no other laser damage (like melting) observed, all damage was in the form of unipolar arc damage.

Publications:

F. Schwirzke, "Laser Induced Unipolar Arching," Laser Interaction and Related Plasma Phenomena, Vol 6, 335-352, edited by H. Hora and G. H. Miley, Plenum Press, 1984

F. Schwirzke, "Unipolar Arching, a Basic Laser Damage Mechanism," Laser Induced Damage in Optical Materials, NBS Special Publication, U. S. Department of Commerce, National Bureau of Standards, 1982.

F. Schwirzke, "Unipolar Arc Model," Journal of Nuclear Materials Vol. 128 and 129, "forthcoming".

F. Schwirzke, "Short Pulse Laser and Plasma Surface Interactions," NPS Technical Report, NPS-61-84-004, 2 April 1984.

Conference  
Presentation:

F. Schwirzke, "Unipolar Arc Model," Poster presentation, 6th International Conference on Plasma Surface Interactions in Controlled Fusion Devices, Nagoya, Japan, 14-18 May 1984.

Title: Atmospheric Optics Instrumentation and Measurements

Investigators: D. L. Walters, Associate Professor of Physics

Sponsor: NPS Foundation Research Program

Objective: To acquire and fabricate the instrumentation needed to perform electro-optical measurements of atmospheric turbulence parameters that degrade laser propagation and initiate field measurements.

Summary: An extensive effort was completed to select the best possible computer system for field data collection and processing, within cost, size, performance, and long term expansion constraints. The Hewlett-Packard series 200 computer was ultimately chosen and acquired over previously used Digital Equipment computers. With this critical decision made, auxiliary components were selected, purchased and acquired. Three designs of an instrument to measure the isoplanatic angle-a critical high energy laser atmospheric parameter-were evaluated and two designs were fabricated. Field measurements began at NPS in August.

Publications: A draft open literature paper "Isoplanatic Angle Measurement", has been written and is waiting for the inclusion of specific experimental measurements that verify the design compromises.

Conference Presentation: D. L. Walters, "Isoplanatic Angle Measurements", Optical Society of America Annual meeting, New Orleans, Oct. 1983.

Thesis Directed: E. Kim, "Noise Characteristics of a Silicon Avalanche Photodiode," Master's Thesis, December 1984.

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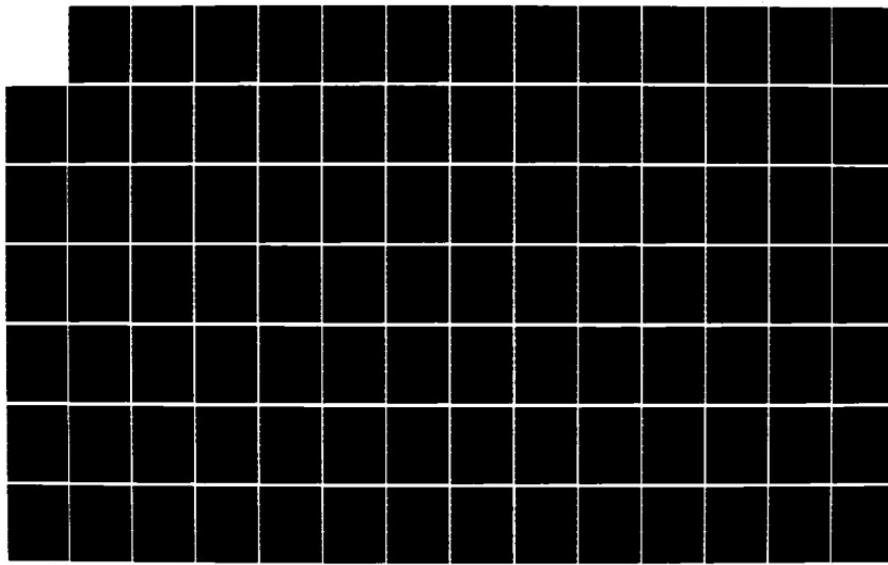
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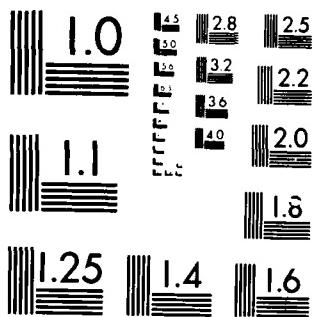
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Title: Isoplanatic Angle Systems Development and Measurement Program

Investigators: D. L. Walters, Associate Professor of Physics

Sponsor: Defense Advanced Research Projects Agency

Objective: To design and implement techniques to measure the atmospheric isoplanatic angle and to perform seasonal measurement of this parameter at White Sands Missile Range, NM and at NPS. This program is an outgrowth of the NPS Foundation program Atmospheric Optics Instrumentation and Measurements that provided seed funding.

Summary: Two isoplanatic angle systems were designed and fabricated. Testing at NPS during August, 1984 showed that the first design that used parallel optical and electronic processing could not maintain balanced operation over moderate temperature changes. Sky background suppression is a critical element in daytime stellar observations and accurate balancing between the two optical signals is required to extract useful atmospheric information. A single channel design was implemented that included a high speed chopper for background suppression. A successful measurement session was completed at White Sands Missile Range, NM, during Sept. 1984. Analysis of this data is underway.

Publication: Results of the September measurements at White Sands Missile range will be included in the paper "Atmospheric Isoplanatic Angle Measurements".

Conference Presentation: D. L. Walters, "Atmospheric Isoplanatic Angle Measurements", DoD HELRIG Workshop, Kirtland AFB, NM, 18 February 1984.

Theses Directed: K. Stevens, "Inversion of a Fredholm  
Equation to Determine the Index Refraction  
of the Atmosphere vs. Altitude," Partial  
fulfillment of Ph.D. Dissertation,  
September 1985.

E. Kim, "Noise Characteristics of a Silicon  
Avalanche Photodiode," Master's Thesis,  
December 1984.

**DEPARTMENT  
OF  
ELECTRICAL AND  
COMPUTER ENGINEERING**

## DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

### INTRODUCTION

The research program of the Department of Electrical and Computer Engineering involves projects in the following areas: signal processing; electro-magnetics; communications; computer engineering; radar and electronic warfare; and command, control, communications and intelligence ( $C^3I$ ) systems. Summaries of the current projects follow.

### SIGNAL PROCESSING

Professor Lonnie Wilson's project on automatic radar ship classification capabilities for cruise missiles focussed on the development of new target classification capabilities for cruise missile applications. Processing techniques have been developed for automatic target classification based on pattern recognition and advanced correlation techniques. Artificial intelligence concepts have been introduced to aid the decision-making. Professor's Wilson's work has developed several ship target classification algorithms that have been successfully tested on a small number of ship targets.

Professor Sydney Parker continued work on projects while on sabbatical leave at Stanford University. This work includes development of multidimensional and nonlinear signal processing algorithms for system modeling, identification and digital filtering. Additionally work has been done on extending the one-dimensional lattice parameter modelling used in voice processing to two dimensions for enhance processing of voice, images, two dimensional recursive filter design and two dimensional spectral estimation.

NAVELEX Chair Professor Ron Mohler work on nonlinear signal processing techniques applied to the underwater acoustic tracking problem of tracking a maneuvering platform.

Adjunct Professor Sherif Michael has been investigating improved operational amplifier specifications that can result when standard op amps are combined into composite operational amplifier configurations. The performance of the combination can be made superior to that of the single op amps. Work is proceeding on the characterization of generalized emittance convertors in both theory and experiment.

### COMMUNICATIONS

Adjunct Professor Daniel Bukofzer has been working on an analysis of a receiver in the presence of noise and an intentional interference signal. The goal is analyze the vulnerability of receivers to jamming, and then to optimized the receiver design to operate in the present of jamming waveforms. He examined performance analyses of coherent and incoherent binary receivers and has extended the technique to multi-level transmission schemes such as M-ary ASK and FSK.

Professor Hung-Mou-Lee and Professor Dick Adler have been studying the properties of antenna patterns of field-expedient antennas used by the Marine Corps and have implemented a design selection technique suitable for use on a microcomputer.

Professor Larry Ziomek worked on modelling underwater acoustic propagation and scattering using linear systems models. Problems in pulse propagation, underwater acoustic communication, and target detection were studied using computer simulation of a mathematical model that has been derived. A three-dimensional beam forming algorithm was developed for use in studying these problems.

Professor John Powers investigated problems in underwater date transmission by fiber optic cables. One project investigated the survivability of a candidate fiber cable when towed by a ship by an experimental investigation. Similar cables are also being investigated for over-the-shore applications. Instrumentation has been developed for measuring the bit-error performance of ocean-floor systems using a battery-operated CMOS microprocessor that will perform the bit-error test at preprogrammed intervals.

Professor Paul Moose initiated research on the development of a high data rate underwater acoustic communications link using a coherent multi-tonal PSK emitter. Work was done on designing and testing the message generator while other components were gathered for assembly of a laboratory prototype.

Adjunct Professor Dick Adler performed work on numerical models of antennas for various military applications. Various candidates were studied and evaluated for performance.

#### RADAR AND ELECTRONIC WARFARE

Professor Michael Morgan investigated techniques of target identification by reason ant responses to electromagnetic waves. Work has continued on the analysis of the response of simple geometries to pulse irradiation. Additionally improvements have been made to the hardware used in collecting experimental data and in the signal processing of this data. In other project Professor Morgan is using the transient scattering response of models to predict the radar cross section of actual targets. Work has concentrated on s-plane measurement and deconvolution techniques to remove the effects of the input impulse.

Professor Hung-Mou Lee has been working on the errors that can occur in extrapolating the predictions based on point-source assumptions made in the analyses of monopulse radars to the detection of extended objects (as is commonly done in the literature).

## COMPUTER ENGINEERING

Professor Chin-Hwa Lee has been working on problems in image processing. In one project he has established test procedures to be used to evaluate contractor algorithms for image segmentation techniques. Another project involves research on region segmentation to decrease processing loads. He is investigating recursive splitting techniques using a special data structure made possible by virtual memory computers. Techniques for handling the discontinuous boundaries created by some of the techniques have also been studied. In another project, he has studied techniques of achieving data compression of the information in an image by splitting the image into irregular patches.

Professor Don Kirk and Bob Strum have been applying VLSI design techniques. A pipelined multiplier chip was designed, fabricated, and tested successfully.

Adjunct Professor Herschel Loomis has been working on computer architecture and algorithm issues for tactical applications of space systems. Additionally he has been working on problems of computer signal processing of signals using the cyclic spectrum of noisy signals, investigating architecture issues that could improve signal processing and defining a special-purpose language for signal analysis.

## ELECTROMAGNETICS

Professor Hung-Mou Lee has been studying the theory of scattering from finite-length cylinders to analytically predict the waves. The theory computes the induced surface currents and from them the scattered fields. Efforts are being made to correlate the predicted fields with observations.

Professor John Powers and NRC Research Associate Daniel Guyomar worked on the propagation of pulsed scalar waves in lossy and lossless media. Computer algorithms were developed for predicting the field for different loss models and boundary conditions. The resulting approaches can be applied to acoustics, optics and electromagnetic waves.

## CONTROLS

Professors Don Kirk and Bob Strum have been studying performance measures for the design of constant-gain estimators through design simulations. Additionally, measures were developed to determine the observability of the state of a system. Finally CAD tools were developed for the design and analysis of controlsystems with constant-gain estimators.

Professor Alex Gerba worked on the simulation of a brushless DC motor for application as a fin controller on a cruise missile. This work developed models of the candidate motors with the use of CSMP models for evaluation. Additionally work was done on designing and evaluating a pulse-width modulationspeed controller for these motors.

## COMMAND, CONTROL AND COMMUNICATIONS

NAVELEX Chair Professor Ron Mohler worked on applying bilinear systems theory to problems in C<sup>3</sup>. The technique can be applied to maneuvering rigid bodies, combating forces, adaptive command and control systems, and the hierarchy of the national C<sup>3</sup> system. Additionally work has also been done on applying bilinear system theory to pursuit-evasion problem , particularly to multiple pursuer cases where the command and control requirements increase rapidly with the number of pursuers.

Professor Paul Moose and John Wozencraft worked on mathematical modelling of the forces engaged in dynamic warfare. The model shows that the evolution of a battle is primarily a function of the initial conditions and that optimum decisions can be made from knowledge of those conditions. The resulting paradigm has been successfully tested against historical battles held since World War II.

Professor Lonnie Wilson is working on research in sensor integration to track multiple targets. The purpose is to integrate sense information from ESM, radar, IR/EO, and acoustic sensors in a central location for advanced combat direction.. Aspects of implementing the integration with computers and applying artificial intelligence concepts are being investigated.

TITLE: Numerical Models for HF Antennas

INVESTIGATORS: R. W. Adler, Adjunct Research Professor, Electrical and Computer Engineering Department.

SPONSOR: US Army

OBJECTIVE: Develop numerical models for sky and ground wave communication antennas and conduct a parameter investigation for various tactical applications.

SUMMARY: Fan doubler, squashed rhombic, sloping longwire and inverted L antennas were modeled. Problems with catenary effects on the long spans require development of an additional code, scheduled for completion June 1985.

TITLE: Field Expedient Antenna Investigations

INVESTIGATORS: R. W. Adler, Adjunct Research Professor and H. M. Lee, Assistant Professor, Electrical and Computer Engineering Department.

SPONSOR: Naval Ocean Systems Center

OBJECTIVE: Numerical modeling research on field expedient USMC antennas for development of an antenna selection and design algorithm for use with the prophet system.

SUMMARY: 27 HF and VHF antenna models were developed. A class of these were subjected to field performance measurements. The sensitivity to ground environments was established and used for selection of candidates for inclusion in a files antenna handbook.

THESIS DIRECTED: W. P. Averill, "Computer Aided Antenna Design and Frequency Selection for HF Communications", Master Thesis, June 1984.

TITLE: Portable VLF Antenna Modeling

INVESTIGATORS: R. W. Adler, Adjunct Research Professor, Electrical and Computer Engineering Department.

SPONSOR: Naval Ocean Systems Center

OBJECTIVE: Development of performance specifications for a portable VLF antenna system using numerical modeling techniques.

SUMMARY: Numerical models of ground screens both buried and above ground were developed in the form of a parameter variation study.

TITLE: Performance of Optimum and Suboptimum Incoherent Digital Communications Receivers in the Presence of Noise and Jamming

INVESTIGATORS: D. C. Bukofzer, Assistant Professor of Electrical and Computer Engineering

SPONSOR: Naval Electronic System Command

OBJECTIVE: To determine jamming vulnerability of conventional digital communication receivers.

SUMMARY: Optimum jamming strategies for binary communication receivers were derived and analyzed and alternate jamming waveforms were investigated. Performance analyses were undertaken in order to determine jammer effectiveness. Coherent and Incoherent Binary Receivers were analyzed as well as multilevel schemes such as M-ary ASK and FSK.

PUBLICATIONS:

D. C. Bukofzer, "Performance of Optimum and Sub-optimum Incoherent Digital Communication Receivers in the Presence of Noise and Jamming," IEEE Transactions on Aerospace and Electronic Systems, in progress.

D. C. Bukofzer, "On the Jamming of Digital Communication Receivers: Results for Coherent Binary and Multilevel Modulation," IEEE International Symposium on Information Theory, forthcoming.

D. C. Bukofzer, "Performance of Noncoherent Binary Receivers Under Various Types of Jammers," IEEE International Symposium on Information Theory, forthcoming.

THESIS DIRECTED:

F. T. Farwell, "An Analysis of Coherent Digital Receivers in a Jamming Environment," Master's Thesis, June 1984.

H. Y. Joo, "Performance of Noncoherent Digital Receivers in the Presence of Jamming," Master's Thesis, December 1984.

D. Macone, "A Study of the Use of Filter in Digital Receivers Operating in a Jamming Environment," Master's Thesis, December 1984.

TITLE: Brushless DC Motor Simulation Project

INVESTIGATORS: Alex Gerba, Associate Professor of Electrical and Computer Engineering.

SPONSOR: Naval Weapons Center

OBJECTIVE: To simulate a brushless DC motor as a fin controller for a cruise-type missile.

SUMMARY: The development of a CSMP model using average power conditioner and motor characteristics at constant speed has been completed. Several versions of the model that are useful for steady-state speed, current and power versus torque analysis and design were developed. These models include the condition of constant air gap flux as well as sinusoidal and sinusoidal with harmonic air gap flux. Rotor position sensors based upon Hall Effect were simulated to switch power transistor for communication in accordance with logic dictated by a four-pole magnet rotating under Y-connected 3 phase windings.

Concurrent to the above effort, the CSMP model of a speed controller using Pulse Width Modulation (PWM) has been completed. Studies were conducted to establish the effectiveness of this method of speed control under constant flux operation. Results of the investigation verified that power losses within the switching transistors are minimized with resulting savings in transistor cost and heat sink requirements.

THESIS DIRECTED: S. M. Thomas, CSMP Modeling of Brushless DC Motors, MSEE Thesis, Sept. 1984.

Andrew Askinos, Pulse Width Modulated Speed Control of Brushless DC Motors, MSEE Thesis, Sept. 1984.

TITLE: Control System and VLSI Design Studies

INVESTIGATOR: D. E. Kirk, Professor of Electrical and Computer Engineering and R. D. Strum, Professor Electrical and Computer Engineering

SPONSOR: Strategic Systems Project Office

OBJECTIVE: The objectives are to develop computer-aided techniques and apply them to control design tasks of interest in the Trident II Program and to utilize VLSI design techniques to develop components for high-speed digital filters.

SUMMARY: Three performance measures were investigated for the design of constant-gain estimators. The (simulated) performance of worst-case and mean quadratic integral error squared was better than that observed for other performance measures. The approach used was also extended to allow determination of worst-case and best-case performance for a given observer. This allows consideration of sensitivity to initial errors. Finally, the technique was used to develop measures of the relative observability of a system's state, an area of continuing investigation. The goal is to develop a way to determine the performance benefits that result if different sensors are used to obtain state measurements. Or, an understanding may be obtained of the limitations inherent in the system with respect to the estimation of the various states from output measurements. A second area of investigation was the development of interactive Computer-Aided Design (CAD) tools for analysis and design of control systems. These tools were then applied to the TVCEEC problem. It was shown that constant gain observers performed as well as Kalman filters considered in previous work, but sensitivity to plant parameter variations is still a problem.

The VLSI design studies were concerned with the development of a pipelined multiplier. The multiplier were designed using the MacPitts silicon compiler. After extensive simulation, the design was sent for fabrication. The fabricated chip was tested to the limits of our capability, and is functionally correct. Additional tests are needed to determine the maximum speed at which the circuit can be operated.

THESIS DIRECTED:

Frank Forkel, "Design and Sensitivity Analysis of an Optimal Observer for the Trident II Missile TVC-EEC Control System," Master's Thesis, December 1983.

Alden Hingle, "A Study of Quadratic Performance Measures in Observer Design," Master's Thesis, December 1983.

Dennis J. Carlson, "Application of a Silicon Compiler to VLSI Design of Digital Pipelined Multipliers," Master's Thesis, June 1984.

TITLE: Advanced Antiship Targeting Program

INVESTIGATOR: C-H Lee, Associate Professor of Electrical and Computer Engineering

SPONSOR: Naval Weapons Center

OBJECTIVE: To help develop classification algorithm on flying platform

SUMMARY: This task is to provide a testing facility for evaluation of image segmentation algorithms from five contractors: Ford Aerospace, General Dynamics, Hughes Aircraft, RCA and McDonnell Douglas Corporation. A test facility at the Naval Postgraduate School includes the VAX 11 750 super minicomputer, the COMTAL image processing system, and the appropriate evaluation software. Most of the effort was concentrated on the preparation of the test procedures. The initial segmentor test was scheduled on October 2 to 4. The results will be published and distributed among members of the community.

PUBLICATIONS: C-H Lee, "AATD Segmentor Test General Procedure," NPS Research Report, November 1984.

THESIS DIRECTED: Werawong Thavamongkon, "Ship Outline Feature Selection Using B-Spline Function," Master's Thesis, December 1984.  
Stephen S. Payne, "Ship Target Recognition Using Multiple Frame Data," Master's Thesis, June 1985.

TITLE: Image Processing Research

INVESTIGATOR: C-H Lee, Associate Professor of Electrical and Computer Engineering

SPONSOR: Naval Electronic Systems Command

OBJECTIVE: Applying the algorithm of recursive segmentation with hierarchical scope views to digital aerial photographs. The purpose is to investigate the sensitivity improvement of this algorithm.

SUMMARY: The purpose of this work is to conduct basic research addressing problems related to image processing. This research is to address both computer analysis and hardware implementation aspects of image processing using concise spatial features of irregular piecewise polynomial surfaces. Implementation of this feature extraction procedure in VLSI shall be considered. A large computer may be used for both verification of the process and design of the hardware.

One goal of this work is to improve the performance of existing algorithms for region segmentation applied to high resolution aerial photographs. A Recursive Splitting method at hierarchical scopic levels will be developed and implemented. This requires a special data structure constructed in the memory space of the computer. To evaluate this scheme, it is necessary to implement this structure in a virtual memory machine. The iteration criterion in the algorithm will include diagonal profile consideration. Special problems caused by discontinuous boundaries from splitting at different levels will be solved by "adjacency propagation of thresholds".

PUBLICATIONS: L. Souza and C-H Lee, "Fundamentals of Systolic Array Computers," NPS Research Report, November 1984.

THESIS DIRECTED: H. S. Hwang, "Computer Display of 3-D Data," Master's Thesis, December 1984.

L. J. DeSouza, "Algorithmic Study of Systolic Array," Master's Thesis, June 1985.

TITLE: Image Data Compression and Representation by Piecewise Surfaces Over Irregular Patches

INVESTIGATOR: C-H Lee, Associate Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

OBJECTIVE: This is a study of the surface representation of image data. An image surface can be presented as a collection of irregular patches of parametric spline surfaces. This study is concentrated on maximizing the achievable data compression ratio.

SUMMARY: One of the important issues in processing digital images is related to the total volume of data involved. How to store the images, how to retrieve them, and how to process them in realistic time? Many efforts were spent in investigating clever ways to code the image so that the total data is compressed. For a regular 512 x 512 element picture with 256 levels of gray it is necessary to required a storage capacity of 64 binary megabytes ( $2^{26}$ ) to accommodate it. For multiple-image processing or change detection in a sequence of time frame images the storage capacity problem becomes serious quickly. The research effort proposed here is aimed at the image data compression problem.

PUBLICATIONS: C-H Lee, "Restoring Spline Interpolation of CT Images," IEEE Transaction on Medical Imaging, Volume MI-2, No. 3, pp. 142-149, September 1983

C-H Lee, "Recursive Region Splitting at Hierarchical Scope Views," submitted to Computer Vision, Graphics and Image Processing, in progress.

THESIS DIRECTED: C. T. DeMiranda, "Image Data Compression Using Uneven Knot Positions," Engineer's Degree Thesis, June 1984

TITLE: Field Expedient Antenna Investigations

INVESTIGATOR: H-M Lee, Assistant Professor of Electrical and M.  
Computer Engineering and R. W. Adler, Adjunct  
Professor of Electrical and Computer Engineering

SPONSOR: Naval Ocean Systems Center

OBJECTIVE: Theoretical investigations and field testing of field  
expedient antennas currently in use by the U.S.  
Marine Corps.

SUMMARY: Field expedient antennas currently in use by the U.S.  
Marine Corps and Navy Seals were investigated and  
field tested. Antenna selection and design algo-  
rithms were implemented on a microcomputer. An up-  
graded version of the USMC Field Antenna Handbook was  
produced.

PUBLICATIONS: USMC Field Antenna Handbook (upgrade)

THESIS DIRECTED: W. P. Averill, "Computer-Aided Design and Frequency  
for HF Communications," Master's Thesis, June 1984.

TITLE: Perturbative Model Analysis of the Back-Scattering Characteristics of a Missile over Several Frequency Bands

INVESTIGATOR: H-M Lee, Assistant Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

OBJECTIVE:

- (1) To develop an analytic theory on the scattering of electromagnetic waves from tubular cylinders of finite length. This will add to the list of only a few finite sized objects of which the vector scattering problems have been analytically solved.
- (2) To apply this theory toward the identification and the reduction of the cross sections of targets with increasingly complex shapes.

SUMMARY: A theory of the scattering surface current on a tubular cylinder was developed and is now being compared to experimental results. Based on this theoretical understanding, scattering data from models with small deviations from a tubular cylinder will be interpreted. Phenomenological theories on these perturbed models will be developed.

CONFERENCE PRESENTATIONS: H-M Lee, "Interaction of Modal Currents on a Tubular Cylinder of Finite Length," 1984 URSI & IEEE AP-S International Symposium at Boston.

THESIS DIRECTED: Mario Loric, "Radar Target Identification through Electromagnetic Scattering Studies," Master's Thesis, December 1984.

TITLE: Inherent Tracking Errors of a Monopulse Radar

INVESTIGATOR: H-M Lee, Assistant Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

OBJECTIVE: To study the inherent angular tracking errors of monopulse radars and to develop, based on the findings of this study, countermeasures against this type of radar.

SUMMARY: A radar is designed for tracking a point target but is always used for tracking a complex target. This will result in errors in the estimated target location by the radar. This type of error has been discussed over the previous 25 years without its origin being recognized. Related problems have been over-simplified and journal publications have been infested with erroneous claims. This research is intended to point out the inadequacies in previous work and to lay the foundation for future developments in this area.

THESIS DIRECTED:

Dae Hyun Park, "Inherent Angular Tracking Error in an Amplitude Comparison Monopulse Radar," Master's Thesis, December 1984.

Sopon Bumroongpol, "Angular Tracking Error in a Phase Comparison Monopulse Tracking Radar: A Critical Review and Extension of the Phase Front Distortion Approach," Master's Thesis, December 1984.

TITLE: Research and Development of Computer Algorithms for Search Systems

INVESTIGATOR: H. H. Loomis, Jr., Adjunct Research Professor of Electrical and Computer Engineering

SPONSOR: Department of Defense

OBJECTIVE: This project is concerned with the development of hardware architectures and algorithms to support specific projects of the Office of Search.

SUMMARY: We have been conducting research to support the objectives of this project in three areas:

- a. The evaluation of candidate algorithms for computing the cyclic spectrum of noisy signals. This has involved extensive simulation studies of signal processing functions developed by Dr. William Gardner.
- b. The investigation of architectures for high speed signal processing making use of pipeline techniques in particular. In this area, we have studied the architecture and performance of a pipeline structure optimized to achieve high performance in the calculation of FFTs. We have also developed some theoretical results on the design of pipelined digital filters.
- c. The definition of a language to define the structure of complex digital communication signals.

PUBLICATIONS: H. H. Loomis, Jr. and B. Sinha, "High Speed Realization of Recursive Digital Filters," to appear in Circuits and Signal Processing, Vol. 3, No. 3, 1984.

J. Pride, H. H. Loomis, Jr., and W. Hickey, "A Signal Descriptor Language," to appear in Cryptologic Quarterly, National Security Agency, 1985.

THESIS DIRECTED: Laurvick, C. A., "Detection of Spread Spectrum Communication," Masters Thesis, June 1984.

Thomas Lorenzo, Jr., "Design Considerations of Pipeline Array Processors", Masters Thesis, December 1983.

TITLE: Applications of Composite Operational Amplifiers in Linear and Non-linear Networks

INVESTIGATOR: Sherif Michael, Adjunct Professor of Electrical and Computer Engineering

SPONSOR: Unsponsored

OBJECTIVE: To investigate the advantages of using the composite operational amplifiers in different analog circuits.

SUMMARY: Recently, a general approach for designing controlled sources by combining N OAs has been proposed by the investigator with applications to Voltage Controlled Voltage Sources (VCVS). The new resulting Composite Operational Amplifier families (CNOAs), were designed according to a stringent performance criterion satisfying practical aspects such as dynamic range, Extended BW, insensitivity to components and GBWP, stability using real OA model, etc. In this ongoing research, application of C2OAs (where N=2) in improving the performance of Generalized Impedance Converters (GIC) is investigated theoretically and experimentally. The research also evaluates similar applications in nonlinear networks.

PUBLICATIONS:

S. Michael and W. B. Mikhael, "High Frequency Active Generalized Impedance Converters and Their Applications in Filtering," Proceedings of the 26th Midwest Symposium on Circuits and Systems, Puebla, Mexico, August 1983, pp. 597-601.

S. Michael and W. B. Mikhael, "High-Speed, High-Accuracy Integrated Operational Amplifiers," Proceedings of the 27th Midwest Symposium on Circuits and Systems, Morgantown, WV, June 1984.

S. Michael and W. B. Mikhael, "High Frequency Filtering and Inductance Simulation Using New Composite Generalized Impedance Converters," Proceedings of the IEEE International Symposium on Circuits and Systems, Kyoto, Japan, forthcoming.

CONFERENCE PRESENTATIONS:

S. Michael, "High-Speed, High-Accuracy Integrated Operational Amplifiers," 27th Midwest Symposium on Circuits and Systems, Morgantown, WV, June 1984.

TITLE: Naval Electronic Systems Command Research Chair in Electrical and Computer Engineering

INVESTIGATOR: R. R. Mohler, NAVELEX Research Chair Professor, Department of Electrical and Computer Engineering

SPONSOR: Naval Electronic Systems Command

OBJECTIVE: Application of bilinear system methodology to C<sup>3</sup> problems.

SUMMARY: Briefly, it has been shown that coupled bilinear systems (BLS) play a very significant role in C<sup>3</sup> problems because of their natural evolution for maneuvering rigid bodies, for combating forces (of which Lanchester's equations are special cases), for high-performance adaptive command and control, and for accurate approximations of more highly nonlinear C<sup>3</sup> processes. It is interesting that the human immune defense system, like many national defense C<sup>3</sup> processes, may be modeled as a BLS hierarchical structure. For both cases, it is the variable-structure or adaptive nature that allows the "alien" to be controlled.

Pursuit-evasion problems that have been studied include minimum-time and minimum-quadratic performance (error and fuel) for competing forces. In particular, linear models with n-pursuers "capturing" a target within some radius has been studied as an extension of the one-on-one solution. Improved performance vs C<sup>3</sup> complexity has been analyzed for n-pursuers as compared to one pursuer or more. It is seen that command, control, computation and communication between objects (e.g. ships or planes) increases significantly with additional pursuers. On the other hand, two or three pursuers, strategically located, can "capture" an otherwise extremely elusive evader. While these results have been derived by preliminary analyses and numerous computer simulations, the general n-pursuer problem is still unsolved. Approximating techniques using a combination of one-on-one configurations in an "ensemble" are being investigated.

TITLE: Nonlinear Filtering and Tracking

INVESTIGATOR: R. R. Mohler, NAVELEX Research Chair Professor,  
Department of Electrical and Computer Engineering

SPONSOR: Office of Naval Research

OBJECTIVE: Development of new nonlinear signal processing methodologies appropriate for acoustical underwater tracking.

SUMMARY: Related research on nonlinear filtering has studied localization of point targets by means of nonlinear observations. Maneuvering targets have been studied, and effective algorithms derived which depend on smoothing of the error residuals and adaptively re-initializing the tracking scheme. The method is applicable to standard (linear or nonlinear) processors with improved performance for maneuvering cases. Other studies include target observability in terms of maneuvers, number of receivers, and receiver information (such as range, bearing, Doppler, etc.). The theory is relevant to not only aircraft and sea-born surveillance but also to satellite-based systems.

TITLE: Acoustic Tactical Data Link

INVESTIGATOR: P. H. Moose, Associate Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

SUMMARY: Based on the feasibility analysis conducted by LT John Lambert, an ASW student at NPS, we have initiated research activities to develop the various components of a high data rate underwater acoustic communications link. A message generator and encoder has been completed during the summer of 1984. The coherent multi-tonal, phase shift keyed digital transmitter is being designed as a thesis project by an ECE student, LCDR DeFrank. A parametric acoustic projector has been acquired from NUSC/NL. Foundation funds were used to purchase the 1500 volt power supply required to operate this transducer.

Plans for 1985 are:

- 1) To conduct research on the digital sonobouy receiver.
- 2) To test the transmitter with the parametric projector for power output, directionality and signal fidelity. Funding will be sought from external NPS sources.

TITLE: Dynamics of Battles, Encounters and Engagements and the Correlation of Forces in Information Driven Warfare

INVESTIGATOR: P. H. Moose, Associate Professor of Electrical and Computer Engineering and J. M. Wozencraft, Professor of Electrical and Computer Engineering

SPONSOR: None

OBJECTIVE: To understand the dynamics of modern warfare and to be able to define the possible outcomes of battle with various force mixes.

SUMMARY: During the past two years, we have investigated evolution mathematics specialized toward battles involving mixtures of high technology weapons and conventional forces. A number of preliminary results have been obtained: an optimum force mixture at each stage of the battle, optimum initial commitment of forces vice forces held in reserve, conditions for successful defense of positions already occupied until reinforcements arrive, and the relative level of high technology weapons to insure initial victories.

All of these results are theoretical. However, some data from post WW II battles have been examined to determine that our paradigm is not grossly incorrect. But what is emerging from our studies is potentially more significant than any of these results. To the extent that evolution mathematics provides an instructive model of Battles nd Engagements, we now know that the trajectory of the battle in the state space of component losses is ultimately restricted to travel in a "tube". The location of this "tube" in the state space is determined by the relative characteristics of the weapons and effectiveness of the combat forces as well as the logistic system that keeps them supplied. This is our conception of "Correlation of Forces". Given a particular tube then the combat loss trajectory will be "attracted to the tube" if the initial conditions of the Battle locate the start point outside it. Once inside the tube, the trajectory is trapped inside it, that is, the loss trajectory travels parallel to the "walls of the tube". The direction of travel, that is who is winning or who is losing, is determined by the "polarity of the tube". The tube's polarity is another of the deterministic properties of this model and it reverses as the tube passes through equilibrium points.

PUBLICATIONS: John M. Wozencraft and Paul H. Moose, "Lanchester's Equations and Game Theory," Proceedings of the 6th MIT/ONR Workshop on C<sup>3</sup> Systems, June 1983.

THESIS DIRECTED: B. N. Ang, "Equilibrium Solutions, Stabilities and Dynamics of Lanchester's Equations and Optimization of Initial Force Commitments," Master's Thesis, September 1984.

TITLE: Measurement of Natural Resonance Parameters for Radar Target Identification

INVESTIGATOR: M. A. Morgan, Associate Professor of Electrical and Computer Engineering

SPONSOR: Office of Naval Research

OBJECTIVE: To advance the state of the art in experimental and theoretical techniques for radar target identification through the use of natural resonances extracted from scattered echo signatures.

SUMMARY: Theoretical and experimental work in the areas of target recognition and imaging via transient scattering responses has been an ongoing effort at the Naval Postgraduate School (NPS) for the past 5 years. This research was initially sponsored through the NPS Research Foundation and was first approached via direct target imaging. This continued effort, sponsored by ONR, utilizes natural resonances.

There are three particular aspects of this present endeavor. The first of these is the continued development and improvement of a computerized experimental facility which synthesizes wide-band resonance region radar returns, and then performs subsequent signal processing to simulate the operations of proposed noncooperative target recognition (NCTR) systems. A second important task will be to catalog the measured natural resonances of a wide variety of radar targets, which are of interest to the Navy, through the use of scale models. A third aspect of this research has been the detailed theoretical analysis of transient scattering and the nature of the natural resonances in the received scattered field. Recent revelations brought forth by this analysis have modified the signal processing strategies that are required for natural resonance NCTR.

PUBLICATIONS:

M. A. Morgan, "Singularity Expansion Representations of Fields and Currents in Transient Scattering," IEEE Trans. on Antennas and Propagation, May 1984, pp. 466-474.

M. A. Morgan, "Time-Domain Scattering Measurements," IEEE Antennas and Propagation Society Newsletter, Feature Article including Front Cover, pp. 4-9.

CONFERENCE  
PRESENTATIONS:

M. A. Morgan, M. L. Van Blaricum, J. R. Auton, "On the Practicality of Resonance-Based Identification of Scatters," 1984 URSI National Radio Science Meeting, Boston, MA, June 1984.

THESIS DIRECTED:

"Development, Calibration and Evaluation of a Free-Field Scattering Range," Manual A. Mariategui, LT, Peruvian Navy, M.S. Thesis, December 1983.

"Investigation of Non-Linear Estimation of Natural Resonances in Target Identification," Choong Y. Chong, LT, Korean Navy, M.S. Thesis, December 1983.

"Radar Target Identification by Natural Resonance Cancellation Filtering," King W. Jean, CPT, Canadian Army, M.S. Thesis, June 1984.

"Investigation of Radar Scattering Reduction by Distributed Methods," Dale E. Stoehr, LCDR, USN, M.S. Thesis, June 1984.

"A Stepped-Frequency Scattering System: Setup and Evaluation," Dennis M. Popiela, LT, USN, M.S. Thesis,

TITLE: Transient Scattering and Signal Processing

INVESTIGATOR: M. A. Morgan, Associate Professor of Electrical and Computer Engineering

SPONSOR: Defense Advanced Research Projects Agency

OBJECTIVE: Using transient electromagnetic scattering measurements from scale model radar targets the broadband RCS is evaluated for Rayleigh and Resonance region frequencies.

SUMMARY: This is a continuing investigation concerning the optimum synthesis of radar cross section (RCS) from transient measurements of scattering. Three particular tasks have received intensive consideration. There has been an in-depth study and measurements concerning s-plane RCS measurement not in the theoretical - experimental study regarding the physical SEM representation of target transient response in the early-time while under driver excitation and to consider the implications of this regarding signal processing strategies and s-plane representation of RCS. Finally, there has been development of an optimal theoretical technique for system deconvolution which will be used for scatterer impulse response synthesis. Near-term future efforts call for the construction of a new anechoic chamber for improved scattering measurements capability.

PUBLICATIONS: M. A. Morgan, "Singularity Expansion Representations of Fields and Currents in Transient Scattering," IEEE Trans. on Antennas and Propagation, May 1984, pp. 466-474.

M. A. Morgan, "Time-Domain Scattering Measurements," IEEE Antennas and Propagation Society Newsletter, Feature Article including Front Cover, pp. 4-9.

CONFERENCE PRESENTATIONS: M. A. Morgan, M. L. Van Blaricum, J. R. Auton, "On the Practicality of Resonance- Based Identification of Scatters," 1984 URSI National Radio Science Meeting, Boston, MA, June 1984.

THESIS DIRECTED:

"Development, Calibration and Evaluation of a Free-Field Scattering Range," Manual A. Mariategui, LT, Peruvian Navy, M.S. Thesis, December 1983.

"Investigation of Non-Linear Estimation of Natural Resonances in Target Identification," Choong Y. Chong, LT, Korean Navy, M.S. Thesis, December 1983.

"Radar Target Identification by Natural Resonance Cancellation Filtering," King W. Jean, CPT, Canadian Army, M.S. Thesis, June 1984.

"Investigation of Radar Scattering Reduction by Distributed Methods," Dale E. Stoehr, LCDR, M.S. Thesis, June 1984.

"A Stepped-Frequency Scattering System: Setup and Evaluation," Dennis M. Popiela, LT, USN, M.S. Thesis, September 1984.

TITLE: Discrete Time Signal Processing for Modeling and Filtering

INVESTIGATOR: S. R. Parker, Professor of Electrical and Computer Engineering

SPONSOR: Office of Naval Research

OBJECTIVE: Research in the development and implementation of algorithms for multidimensional and nonlinear discrete time signal processing for purposes of system modeling, identification and digital filtering.

SUMMARY: It has been shown that by regrouping the terms of a Volterra expansion for a nonlinear system (in the order of a power series, rather than in the order of time delay) a compact tensor notation is possible from which tensor equivalents of the Weiner-Hopf and Yul-Walker equations are possible. The technique has been extended to a basis function expansion, and it has been shown that a simple transformation from one type of expansion to another is possible. Results have been confirmed experimentally, and applied to a recursive least square model approximation which involves the concept of a tensor inverse.

Also, the concept of one dimensional lattice parameter modeling, which has been used so successfully in the past for modeling of the voice tract for speech analysis, synthesis and data compression; has been extended to two dimensional fields. This work represents a fundamental development and has significant ramifications which remain to be investigated. Preliminary applications of this research which have been investigated thus far include: (a) Word recognition based upon the identification of voice prints as images, (b) Image data filtering for data compression, (c) Two-dimensional recursive digital filter design, (d) Two-dimensional spectral estimation.

PUBLICATIONS:

S. R. Parker and A. H. Kayran, "Lattice Parameter Autoregressive Modeling of Two-Dimensional Fields - Part I: The Quarter Plane Case," IEEE Transactions on Acoustics, Speech and Signal Processing, Vol ASSP-32, No. 4, pp. 872-885, August 1984.

S. R. Parker and A. H. Kayran, "Lattice Parameter Autoregressive Modeling of Two Dimensional Fields - Part II: The Half Plane Case," IEEE Transactions on Acoustics Speech and Signal Processing, in progress.

Y. Lim and S. R. Parker, "FIR Filter Design Over a Discrete Powers-of-Two Coefficient Space," IEEE Transactions on Acoustics, Speech and Signal Processing, VOL ASSP-31, No. 3, pp. 583-591, June 1983.

G. A. Clark, S. R. Parker, and S. K. Mitra, "A Unified Approach to Time- and Frequency-Domain Realization of FIR Adaptive Digital Filters," IEEE Transactions on Acoustics, Speech and Signal Processing. Vol 31, No. 5, pp. 1073-1083, October 1983.

Y. C. Lim and S. R. Parker, "On the Synthesis of Lattice Parameter Digital Filters," IEEE Transactions on Circuits and Systems, Vol CAS-31, No. 7, pp. 593-601, July 1984.

A. H. Kayran, Y. C. Lim and S. R. Parker, "Decimation Technique for Optimal Data Transfer in One- and Two-Dimensional FIR Digital-filter implementation," IEE Proceedings, Vol. 131, Pt. G, No. 2, pp. 86-89, April 1984

F. A. Perry and S. R. Parker, "Transition Formulas for Zero-Pole Modeling," IEEE Transactions on Acoustics Speech and Signal Processing, Vol ASSP-32, No. 1, pp. 178-184, February 1984.

Y. C. Lim and S. R. Parker, "On the Identification of Systems From Data Measurements Using ARMA Lattice Models," IEEE Transactions on Acoustics Speech and Signal Processing, in progress.

CONFERENCE:  
PRESENTATIONS:

S. R. Parker, "Modeling of Two-Dimensional Fields with Autoregressive Lattice Parameters," Proceedings of the American Control Conference, WA 9-10:15 San Diego, pp. 216-221, June 1984.

J. J. Thomas and S. R. Parker, "An Implementation of a Fast Recursive Digital Filter Using Single-Modulus Residue Arithmetic," Proceedings of the 1984 International Symposium on Circuits and Systems, May 1984.

A. H. Kayran, S. R. Parker and D. J. Klich, "Two-Dimensional Spectral Estimation with Autoregressive Lattice Parameters," Proceedings of the IEEE 1984 International Conference on Acoustics, Speech and Signal Processing, 1984.

Y. C. Lim and S. R. Parker, "Efficient FIR Filter implementation Using Microprocessor," Proceedings of the 1983 International Conference on Acoustics Speech and Signal Processing, 1983.

Y. C. Lim, A. H. Kayran and S. R. Parker, "A Decimation Technique for Optimal Data Transfer in One- and Two-Dimensional FIR Digital Filter Implementations," Proceedings of the IEEE International Conference on Circuits and Systems, pp. 1079-1082, 1983.

A. H. Kayran, S. R. Parker and H. Canbazoglu, "Design of 2-D Digital Recursive Filters with Autoregressive Lattice Parameters," Proceedings of the IEEE International Symposium on Circuits and Systems, 1984.

C. B. A. Shawcross, S. R. Parker and A. H. Kayran, "Isolated Word Recognition and Speaker Identification Using Two-Dimensional Half-Plane Lattice Parameters of Spectrograms," Proceedings of the International Conference on Digital Signal Processing, September 1984.

S. R. Parker and A. H. Kayran, "Lattice Parameter Autoregressive Modeling of Two-Dimensional Fields," Proceedings of the IEEE ASP Spectrum Estimation Workshop, pp. 219-223. November 1983.

J. J. Thomas and S. R. Parker, "A Viable Technique of Calculating Algorithms to any Specified Accuracy," Signal Processing II: Theories and Applications, pp. 783-786, 1983.

M. Fidan, S. R. Parker and A.H. Kayran, "Calculating Quantization Error Bounds for 2-D Recursive Digital Filters," Signal Processing II: Theories and Applications, pp. 215-218, 1983.

Y. C. Lim, A. H. Kayran and S. R. Parker, "Efficient Positive Coefficient Algorithm for Array Processing,: Electronic Letters, Vol 19, No. 9, April 1983.

THESIS DIRECTED:

D. L. Mauney, "Sensitivity Analysis Modeling for Discrete-time Simulation of Analog Circuitry," Master's Thesis, March 1984.

C. B. A. Shawcross, "The Use of Two Dimensional Lattice Models in Isolated Word Recognition," Engineer's Degree, December 1983.

A. H. Canbazoglu, "Design of Two-Dimensional Recursive Digital Filters Using Lattice Parameters," Master's Thesis, December 1983.

D. Bozkurt, "The Use of 2-D Lattice Modeling for Image Coding and Processing," Master's Thesis, December 1984.

Z. S. Chavez, "Lattice Modeling of an Analog System for Fault Location," Master's Thesis, October 1983.

TITLE: Propagation of Scalar Acoustic Waves

INVESTIGATOR: Daniel Guyomar, National Research Council Associate and John Powers, Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

OBJECTIVE: To apply spatial frequency domain techniques to the modeling to the propagation of pulsed and transient scalar waves in lossless and lossy media. The technique would allow the application of computer-efficient FFT algorithms to problems that have previously used more complicated integrals based on geometrical interpretation.

SUMMARY: Techniques have been identified and used in computer simulations that model the propagation in (1) lossless media, (2) media with an absorption coefficient that is liner with frequency, and (3) media with an absorption that is quadratic in frequency. The techniques have been used to model transient propagation from focused transducers and planar sources. Additionally simplifications have been identified that increase the computational efficiency of the technique in calculating the fields from axisymmetric transducers.

PUBLICATIONS:

D. Guyomar and J. Powers, "Diffraction of Pulsed Ultrasonic Waves in Lossless and Absorbing Media," in progress.

D. Guyomar and J. Powers, "Transient Fields Radiated by Curved Surfaces--Application to Focusing," Journal of the Acoustical Society of America. Vol. 75, pp. 1564-1572, 1984.

D. Guyomar and J. Powers, "Boundary Effects on Transient Radiation Fields from Vibrating Surfaces," Journal of the Acoustical Society of America, forthcoming.

D. Guyomar and J. Powers, "Transient Radiation from Axially Symmetric Sources," in progress.

CONFERENCE:

PRESENTATIONS: D. Guyomar and J. Powers, "Diffraction of Pulsed Ultrasonic Waves in Lossless and Absorbing Media," 107th Meeting of the Acoustical Society of America, Norfolk, VA, 7-10 May 1984.

TITLE: Fixed Distributed Systems: Environmental Acoustics and Fiber Optic Communications

INVESTIGATORS: Calvin Dunlap, Adjunct Research Professor of Oceanography, John Powers, Professor of Electrical and Computer Engineering, Eugene Haderlie, Distinguished Professor of Oceanography and Bryan Wilson, Professor of Physics

SPONSOR: Defense Advanced Research Projects Agency

OBJECTIVE: To investigate the environmental effects on fixed distributed acoustic systems by study of a sample system to be installed in Monterey Bay. Additional study is one the use of fiber optic cables for transmitting the data.

SUMMARY: In this new project a long-wavelength single-mode fiber optic system has been designed for installation at high data rates. Supplies and instrumentation have been identified and ordered for the laboratory construction and testing of the fiber optic link. A candidate fiber cable has been successfully tested in a towing configuration for mechanical robustness. Several over-the-shore fiber links will be installed and periodically evaluated for study of survivability in the surf environment. Additionally, a short course on fiber optic communications was given at NPS to twenty-five project personnel as part of this project.

TITLE: Solid Propellant Combustion

INVESTIGATORS: David Netzer, Professor of Aeronautics, and John Powers, Professor of Electrical and Computer Engineering

SPONSOR: Air Force Rocket Propulsion Lab

OBJECTIVE: To conduct an experimental investigation of the effects of solid propellant properties and motor operating conditions on metallized particulates within the combustor and exhaust nozzle. The techniques investigated are: high speed motion pictures, holography, light scattering, and scanning electron microscopy. Additionally techniques of automatic data reduction from holograms of the particulates were investigated.

SUMMARY: In automatic data reduction, the overlying speckle is observed to limit resolution of the particles. Analysis was performed to identify the source of the limiting speckle size and to modify the recording and reconstruction geometry of the hologram to reduce speckle to a minimum. A Quantimet 720 image processing system was obtained and operator training on obtaining particle size histograms was done using photographs of hologram reconstructions. This system has also been used to examine images from holograms and to measure the speckle. The hologram has been mounted on a digitally controlled stage to provide three dimensional precision motion of the reconstruction volume.

PUBLICATIONS:

J. Powers, D. Netzer, et al, "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," Technical Report AFRL TR-84-014, Air Force Rocket Propulsion Laboratory, Edwards Air Force Base, 1984.

D. Netzer, J. Powers, et al, "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," Proceedings of the 20th JANNAF Combustion Meeting, (Chemical Propulsion Information Agency, Publication No. 883, John Hopkins University Applied Physics Laboratory, Laurel, Maryland, 1984), pp. 319-332.

CONFERENCE  
PRESENTATIONS:

D. Netzer, J. Powers and others, "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," 20th JANNAF Combustion Meeting, Monterey, CA, 17-20 October 1983.

D. Netzer, J. Powers and others, "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," 1984 AFOSR/AFRL Rocket Propulsion Research Meeting, Lancaster, CA, 12-15 March 1984.

THESIS DIRECTED:

L. Klooster, "Image Processing of Solid Propellant Combustion Holograms Using the Quantimet 720," Master's Thesis, December 1983.

TITLE: Multi-Source Track Management

INVESTIGATOR: L. A. Wilson, Associate Professor of Electrical and Computer Engineering

SPONSOR: Naval Sea Systems Command

OBJECTIVE: To develop the Multi-Source Track Management system for the next generation ACDS.

SUMMARY: The theoretical analysis and system tradeoff analysis for the Multi-Source Track Management was continued. The successful integration of ESM, Radar, EO, IR, and Acoustic sensors will significantly benefit ACDS capabilities. Two thesis students have completed efforts on integrating ESM sensor information into the ACDS system. The AN/SLQ-17 ESM system and AN/SLQ-32 system were independently integrated into ACDS. ESM similar source integration, emitter signal sorting, emitter classification, and identification, and emitter classification to platform correlation were included in the analysis.

THESIS DIRECTED: Kenneth G. Lombart, "The Integration of Naval Assets the SSN in ACDS," Master's Thesis, June 1984.

TITLE: Automatic Radar Ship Classification for Cruise Missiles

INVESTIGATOR: L. A. Wilson, Associate Professor of Electrical and Computer Engineering

SPONSOR: Joint Cruise Missile Project Office

OBJECTIVE: To develop automatic radar ship classification techniques and ESM systems for cruise missile applications.

SUMMARY: This research provides theoretical analysis, computer analysis, and system design of an Automatic Radar Ship Classification System for Cruise Missile applications. The primary efforts were centered on classification rates vs. number of ship classes, classification rate vs. ship categories, classification rates vs. radar range resolution, classification rates vs. signal-to-noise ratios, and classification rates for simulated cruise missile seeker signatures. Thesis students participated heavily in this task. The application of artificial intelligence techniques was initiated to help solve the classification problems.

Development of an improved ESM system for Cruise Missile application was started. Experimental Modulation on Pulse (MOP) signatures have been collected for several U.S. radar systems. The wideband MOP measurement system, developed under this task, has much superior performance capabilities when compared with other known systems.

PUBLICATIONS:

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 3 and Resolution No. 3," NPS Working Report, May 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 6 and Resolution No. 3," NPS Working Report, June 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 2 and Resolution No. 3," NPS Working Report, June 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 7 and Resolution No. 3," NPS Working Report, June 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 8 and Resolution No. 3," NPS Working Report, June 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 7 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 6 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 8 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 9 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 2 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 3 and Resolution No. 1," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 1 and Resolution No. 2," NPS Working Report, September 1984.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 2 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 4 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 5 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 6 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 7 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-Ship No. 8 and Resolution No. 2," NPS Working Report.

L. A. Wilson, "Range-Only Radar Ship Signatures-SHIP NO. 9 and Resolution No. 2," NPS Working Report.

THESIS DIRECTED:

Richard D. Snook, "Experimental Measurements of Modulation on Pulse (MOP) Characteristics of Several Radars," Master's Thesis, September 1984.

G. Douglas Thrash, "Experimental Modulation on Pulse (MOP) Characteristics of Selected NPS Radars," Master's Thesis, June 1984.

Paul A. White, "Experimental Frequency Modulation on Pulse (FMOP) Signatures of Selected Radars," Master's Thesis, September 1984.

David Miller, "An Investigation of the Relative Importance of Fourier Phase for Radar Target Classification," Master's Thesis, March 1984.

Scott Boyd, "Frequency Modulation on Pulse Characteristics of the 4J50 Magnetron," Master's Thesis, September 1984.

TITLE: Underwater Acoustic Propagation and Scattering in a Random Ocean - A Linear Systems Theory Approach

INVESTIGATOR: L. J. Ziomek, Assistant Professor of Electrical and Computer Engineering

SPONSOR: NPS Foundation Research Program

OBJECTIVE: To derive transfer functions and coherence functions of the random ocean medium based upon the WKB and parabolic equation approximations. By coupling the transfer functions to various transmit signals and transmit and receive apertures, problems in pulse propagation, underwater acoustic communication, and target detection will be studied via computer simulation of the derived mathematical expressions.

SUMMARY: A time-invariant, space-variant, random transfer function of the ocean volume was derived using the parabolic equation approximation. The ocean volume was characterized by a three-dimensional random index of refraction. The index of refraction was decomposed into a deterministic component and a zero mean random component. In addition, two example calculations were made using the transfer function. The first example involved the derivation of the equations for the random, output electrical signals at each element in a receive planar array of complex weighted point sources in terms of the frequency spectrum of the transmitted electrical signal, the transmit and receive arrays, and the transfer function of the ocean medium. The second example involved the derivation of the coherence function, i.e., the autocorrelation function of the transfer function.

Computer simulation of the equations for the output electrical signals based on the WKB approximation began. A three-dimensional FFT beamformer space-time signal processing algorithm was used to process the computer simulated signals in order to study problems in source localization and underwater acoustic communications.

PUBLICATIONS:

L. J. Ziomek, "Linear Time-Variant Space-Variant Filters and the WKB Approximation," Naval Post-graduate School Technical Report, NPS-62-83-058, October 1983.

L. J. Ziomek, "Linear Time-Invariant Space-Variant Filters and the Parabolic Equation Approximation," Signal Processing, in progress.

**DEPARTMENT  
OF  
METEOROLOGY**

## DEPARTMENT OF METEOROLOGY

The research program in the Department of Meteorology continues in several areas: (1) numerical air and ocean modeling and prediction, (2) dynamics of flow over and around mountains, (3) analysis and dynamics of tropical weather systems, (4) atmospheric boundary layers over the sea and ice, (5) forecasting marine air/ocean parameters using model output statistics, (6) regional weather studies, and (7) satellite remote sensing. Under each of these headings, a number of related investigations have been pursued by various faculty members.

### NUMERICAL MODELING AND PREDICTION

R. T. Williams is developing and testing numerical procedures for global and regional weather prediction. He is investigating various finite element formulations with respect to treatment of small-scale flow fields. He will apply the techniques to the prediction of air flow near mountains, and to tropical cyclones. R. T. Williams and M. A. Rennick are studying topographic effects and the behavior of planetary waves with a spectral baroclinic model. L. C. Chou, R. T. Williams and C.-P. Chang are investigating the "Mei-Yu" rains in China with a moist frontal model.

R. L. Elsberry and R. W. Garwood, Jr. (Oceanography) have used a one-dimensional mixed-layer model to predict the upper ocean response to atmospheric forcing on time scales ranging from diurnal to seasonal changes. In a joint effort with R. L. Haney, the mixed-layer model has been embedded into an oceanic general circulation model. This new model will now be used in a variety of oceanic investigations including the response of the ocean to tropical and extratropical storms (R. L. Elsberry) and the dynamics of the synoptic (mesoscale eddy) scale California Current.

A combined diagnostic-prognostic approach is being used by R. L. Elsberry, C. H. Wash and C.-S. Liou to study maritime extratropical cyclones. The atmospheric model being implemented at the Fleet Numerical Oceanography Center has been used to study the role of air-sea fluxes in extratropical cyclogenesis. Diagnostic studies of the numerically-predicted fields are being made for comparison with similar studies using real data.

Other modeling efforts include (1) a dynamical-statistical model for predicting the movement of tropical cyclones, led by R. L. Elsberry, (2) a marine atmospheric boundary layer model for predicting (6-18 hours) properties which affect radar and optical propagation within the boundary layer and those factors (radiation and boundary fluxes) which affect the upper part of the ocean, directed by K. L. Davidson, and (4) a study on the impact and methods of coupling an ocean mixed-layer model to an atmospheric prediction system (R. L. Elsberry and C.-S. Liou).

### DYNAMICS OF FLOW OVER AND AROUND MOUNTAINS

R. T. Williams and M. A. Rennick are studying the conditions which determine whether or not the air will flow over or around a long mountain

range. The formulation of cyclones in the lee of mountain complexes is being investigated. Also, the interaction of fronts with topography is being considered.

#### ANALYSIS AND DYNAMICS OF TROPICAL WEATHER SYSTEMS

C.-P. Chang, R. L. Elsberry, R. T. Williams and M. S. Peng continue to investigate various aspects of the dynamics of tropical weather systems, including development of hurricanes and typhoons by R. L. Elsberry, the dynamics of tropical synoptic and planetary scale motions and lateral interactions by C.-P. Chang, R. T. Williams and M. S. Peng, and the diagnostic analysis of winter and summer monsoon circulations by C.-P. Chang and M. S. Peng. C.-P. Chang and J. S. Boyle also studied the inter-annual variations of tropical circulations using a ten-year global data base. M. A. Rennick and R. L. Haney are investigating mechanisms of large-scale air-sea interaction in the tropics using coupled numerical models. The work concentrates on ocean temperataure and atmospheric circulation anomalies associated with El Nino.

#### MARINE ATMOSPHERIC BOUNDARY LAYERS OVER THE SEA AND ICE

Research in this area includes several interdisciplinary shipboard/air-craft observational and theoretical projects involving K. L. Davidson and W. J. Shaw. Recent observational projects have occurred in the Marginal Ice Zone of the East Greenland Sea and off the coast of Southern California. Objectives of the individual projects are: (1) to evaluate and formulate models which relate changes in the depth and structure of the atmospheric boundary layer to surface fluxes and sky conditions, (2) to evaluate and formulate models for equilibrium marine aerosol distributions, (3) to establish synoptic-scale description of the magnitude and height variations of optical turbulence, (4) to relate near-surface aerosol distributions to white-cap coverage, (5) to determine dispersion properties of the atmospheric boundary layer in the California coastal region and (6) to evaluate synoptic scale forcing on the boundary processes and evolutions utilizing data from single (*in situ*) stations. Long range objectives of this work are to provide tactical assessment and predictive procedures for electromagnetic, optical and dispersion propertiess of the marine boundary layer. W. J. Shaw is also involved in a measurement effort at Pt. Pinos (Monterey Peninsula), California involving acoustic remote sensing which will relate the overall structure and evolution of the boundary layer to the small-scale structure of turbulence.

#### FORECASTING MARINE AIR/OCEAN PARAMETERS USING MODEL OUTPUT STATISTICS

A multiple-year project directed toward applying the methods of model output statistics (MOS) to forecasting operationally important air and ocean parameters to 48-h, for all oceans of the world continued in FY 1984. The research, involving R. J. Renard, is presently concerned with forecasting surface horizontal visibility, and cloud heights and ceiling, over the North Atlantic Ocean area. Predictor information is being derived from the Navy's Operational Global Atmospheric Prediction System (NOGAPS). Under consideration and testing are maximum-probability and natural regression strategies, linear regression (with various threshold schemes) and discriminant analysis.

## REGIONAL WEATHER GUIDES

Pressure, temperature and vector wind data from the Antarctic remote-site automatic weather stations on/near the Ross Ice Shelf area, and surface and upper-air observations at McMurdo, Antarctica are being analyzed by R. J. Renard and associates for their contribution to regional climatology and improved operational weather forecasting.

F. R. Williams and R. J. Renard continued efforts at developing a weather forecasting digest for the Southern African Continent and the surrounding South Atlantic and Indian Ocean areas. The digest, to be published in FY 1985, will concentrate on synoptic- and mesoscale atmospheric circulations of importance to forecasting for air and sea operations in the area.

## SATELLITE REMOTE SENSING

K. L. Davidson is involved in experimental verification on mechanisms responsible for synthetic aperture radar (SAR) images of the ocean surfaces. Measurements of surface stress are being made on a tower off the California coast, near San Diego, in conjunction with aircraft and Space Shuttle (Shuttle Imaging Radar) overflights. P. A. Durkee is examining the relationship between satellite-detected brightness variations and extinction by aerosols. C. H. Wash is applying interactive computer techniques to GOES and NOAA visual, infrared and other radiometric data to specify cloud and precipitation patterns using the NEPRF Satellite Processing and Acquisition System and the NPS VAX/COMTAL System.

Title: . Evaluation of NOGAPS Tropical and Medium Range Forecasts

Investigators: J. Boyle, Adjunct Professor of Meteorology  
C. H. Wash, Associate Professor of Meteorology  
C.-P. Chang, Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: To evaluate the numerical weather prediction products of NOGAPS with special emphasis on the medium-range (3-5 day) and the tropical forecasts.

Summary: Systematic wind, height and temperature errors for 4 months, 4/83, 11/83, 12/83 and 1/83, have been calculated. Topographical effects and cumulus convection parameterization are likely factors causing these errors. A case study of Asian cold surges in NOGAPS has been completed. It is found that the NOGAPS 24 h forecast always underestimates the jet acceleration due to inadequate divergence representation in the objective analysis. This inadequate representation of tropical divergence seriously under estimates the significant tropical-midlatitude interaction observed during major synoptic activities. Twelve case studies of 120 hr forecasts including 4 cases of NOGAPS 2.0 (one in April 83, 3 in November 83), and 8 cases of NOGAPS 2.1 (4 in Dec 83 and 4 in Jan 84) were conducted. Significant errors were observed in all wavenumber groups by 48 h in 550 mb heights: (1) general lack of amplitude in waves of all groups, (2) planetary waves have as large (if not larger) error than other groups, and (3) a consistent positive error in the polar latitudes. The 2.1 forecasts were judged to be significant improvement, with errors comparable to the 2.0 version occurring at more advanced forecast time.

Publications: C.-P. Chang, and K. G. Lum, "Midlatitude-Tropical Interaction over Asia Pacific during the 1983-84 Winter", Monthly Weather Review, (submitted).

G. T. J. Chen, Y. Wang, and C.-P. Chang, "Evaluation of Surface Prognoses of Cyclones and Anticyclones of the JMA Regional and NOGAPS Models Over East Asian and the Western Pacific during the 1983 Mei-Yu Season", Monthly Weather Review, (submitted).

Thesis directed: R. Showalter, Spectral Decomposition and Verification of NOGAPS 500 mb Medium Range Forecasts, September 1984.

Title: Interactions of Synoptic and Interannual Variations of Large-Scale Motions during Winter

Investigators: Chih-Pei Chang, Professor of Meteorology and K. M. Lau, Visiting Scientist

Sponsor: National Oceanic and Atmospheric Administration

Objective: To study the interannual variations of the large-scale flow over the Asia-Pacific region and their interaction with the synoptic time scales.

Summary: An atlas of the 200 mb circulation field was produced which contains northern winter monthly and seasonal mean wind analyses, velocity potential and streamfunction from 40S to 60N over a global belt for the decade 1973 through 1983. In addition, the deviations of the individual annual seasonal and monthly means from their respective decade means are presented for the same variables. The basic wind data used are the operational Global Band Analyses (GBA) of the Navy's Fleet Numerical Oceanography Center (FNOC). The analyses exhibit many interesting features, interannual variations and shed some light on the understanding of the El Nino/Southern Oscillation phenomena. In particular, the data suggest that atmospheric teleconnection between the tropics and the middle latitudes may be strongly influenced by other processes such as normal mode instability (Simmons et al., 1983), and nonlinear interactions (Lau and Lim, 1983) in addition to factors that are directly related to the equatorial convective heating. A unified view (if there is any) of El Nino/Southern Oscillation calls for a more profound understandings of the phenomenon beyond what can be gained from case-by-case studies.

Publications: K. M. Lau and P. H. Chan, "Short-Term Climate Variability and Atmospheric Teleconnection from Satellite Outgoing Longwave Radiation. I: Simultaneous Relationships," Journal of Atmospheric Sciences, 40, 2735-2750.  
K. M. Lau and P. H. Chan, "Short-Term Climate Variability and Atmospheric Teleconnection from Satellite Outgoing Longwave Radiation. II: Lagged Correlations," Journal of Atmospheric Sciences, 40, 2751-2767.

K. M. Lau, J. S. Boyle and C.-P. Chang, "Anomalous Diabatic Heating and Large-Scale Circulation in the Tropics during the 1976-77 and 1982-83 ENSO's," Tropical Ocean-Atmosphere Newsletter, 24, 12-13.

C.-P. Chang and K. G. Lum, "Tropical-Midlatitude Interaction over Asia Pacific during the 1983-84 Winter," Monthly Weather Review (submitted).

C.-P. Chang, "A Review of Midlatitude Tropical Interaction over Asia Pacific during Cold Surges," Papers in Meteorological Research, 7 (in press).

J. S. Boyle and C.-P. Chang, "Monthly and Seasonal Climatology over the Global Tropics and Subtropics for the Decade 1973 to 1983. Volume I. 200 mb winds," NPS Tech. Rep. 63-84-006, 172 pp.

Conference Presentations:

C.-P. Chang, "Planetary Scale Circulation: Observation and Theory" (INVITED REVIEW), National Academy of Sciences Workshop on TOGA, La Jolla, CA, 13-15 Feb, 1984.

C.-P. Chang, "Midlatitude-Tropical Interactions during Winter Monsoons" (INVITED REVIEW), National Academy of Sciences Workshop on FGGE, Woods Hole, 9-20 July 1984.

Title: Tropical and Monsoon Studies

Investigators: Chih-Pei Chang, Professor of Meterorology and  
R. T. Williams, Professor of Meteorology

Sponsor: National Science Foundation

Objective: To study the structure and dynamics of large-scale flow in the tropics and other areas which are influenced by monsoons. This is a continuing project.

Summary: The 1983-1984 winter 200 mb wind analysis was used to study the cause-effect in the short term interaction between tropical convection and midlatitude jet streaks. Significant positive correlation between the midlatitude jet acceleration and tropical divergence was found in several regions in the Asia-Pacific-Indian Ocean region. Among six major events of the intensification of the West Asian jet streak maximum during December 1983, three were related to tropical cyclone activities and two to cold surges. The tropical cyclone cases led to the conclusion that the midlatitude jet can be influenced effectively by tropical convective activities on a day-to-day basis. This result has possible implications for midlatitude weather forecasting. The study also confirmed the downstream propagation of the jet streaks once strengthened, which is probably due to self-advection, and the existence of thermally-indirect circulations at the exit region of the jet, both in the time-mean and in the transient motion fields. A theoretical study was carried out to analyze further the effects of surface heating, boundary layer pumping, vertical shear and differential damping of motions in response to tropical heating. A two-level model demonstrated that the ratio of the rotational flow amplitudes of the external and the internal modes is  $[ik(U_3 - U_1) - (D_3 - D_1) - f\alpha] : [-ik(U_3 + U_1) - (D_3 + D_1) - f\alpha]$ , where  $U_1$ ,  $U_3$ ,  $D_1$  and  $D_3$  are the mean zonal winds and damping coefficients at the upper and lower levels, and  $(f\alpha)^{-1}$  is the spin down time scale of the Ekman layer. In addition to the above, other studies of the winter and summer monsoon systems have also been carried out.

Publications:

R. T. Williams, H. Lim and C.-P. Chang, "Nonlinear and Linear Effects in an Easterly Jet with Downstream Variation", Journal of Atmospheric Sciences, 41, 621-636.

C.-P. Chang, "A Review of Midlatitude Tropical Interactions over East Asia during Cold Surges", Papers in Meteorological Research, 7, (in press).

K. M. Lau, J. S. Boyle, and C.-P. Chang, "Anomalous Diabatic Heating and Large-Scale Circulation in the Tropics during the 1976-77 and 1982-83 ENSO's", Tropical Ocean-Atmosphere Newsletter, 24, 12-13.

C.-P. Chang, and K. G. Lum, "Midlatitude-Tropical Interaction over Asia Pacific during the 1983-84 Winter", Monthly Weather Review, submitted.

G. T. J. Chen, Y. Wang and C.-P. Chang, "Evaluation of Surface Prognoses of Cyclones and Anticyclones of the JMA Regional and NOGAPS Models Over East Asia and the Western Pacific During the 1983 Mei-Yu Season", Monthly Weather Review (submitted).

H. Lim and C.-P. Chang, "Effect of Vertical Shear and Differential Damping on Waves Forced by Heating", Journal of Atmospheric Sciences (submitted).

Conference Presentations:

A. Shaffer, C.-P. Chang and R. L. Elsberry, "Long-Wave Forcing of Equatorial Penetrating Winter Monsoon Cold Surges", 15th Technical Conference on Hurricanes and Tropical Meteorology, American Meteorological Society, Miami, FL, 9-13 January 1984.

C.-P. Chang, "Planetary Scale Circulation: Observation and Theory" (INVITED REVIEW), National Academy of Sciences Work-shop on TOGA, La Jolla, CA, 13-15 February 1984.

M.S. Peng, R. T. Williams, and C.-P. Chang, "Barotropic Instability in a Slowly Varying Easterly Jet", Joint Conference of the 18th Annual Congress of the Canadian Meteorological & Oceanographic Society and the 11th Annual Meeting of the Canadian Geophysical Union, Halifax, Nova Scotia, Canada, 28 May-1 June 1984.

C.-P. Chang, "Midlatitude-Tropical Interactions during Winter Monsoons" (INVITED REVIEW), National Academy of Sciences Workshop on FGGE, Woods Hole, MA, 9-20 July 1984.

M. S. Peng and R. T. Williams, "Application of Multiple-Scale Technique to Barotropic and Baroclinic Instability of a Current with Slow Zonal Variation", Society of Industrial and Applied Mathematics (SIAM) Summer Meeting, Seattle, WA, 16-20 July 1984.

Title: SHIPBOARD ATMOSPHERIC MEASUREMENTS IN MIZEX-84

Investigators: K. L. Davidson, Professor of Meteorology  
G. E. Schacher, Professor of Physics

Sponsor: Office of Naval Research

Objective: To make shipboard measurements of mean and turbulent properties of the atmospheric surface layer and mixed layer in the Marginal Ice Zone (MIZ) of the East Greenland Sea during MIZEX-84. To coordinate meteorological measurements from all platforms involved in MIZEX-84.

Summary: Continuous meteorological measurements were made from the R/V Hakon Mosby during the period from 16 June to 15 July 1984 in the MIZ. 138 radiosondes were launched from the R/V Hakon Mosby according to the schedule in the MIZEX-84 operations manual (MIZEX Project Office, March 1984). Preliminary analyses are being performed on the recorded data and on the synoptic scale features responsible for wind speed and direction variations during the period.

Conference Presentation: K. L. Davidson, "Scientific Meteorological Questions in the Marginal Ice Zone," Second Alfred-Wegener Conference on Air-Sea-Ice Interactions, Bremerhaven, FRG 14-18 November 1983.

P. S. Guest and K. L. Davidson, "Drag Coefficients Obtained During MIZEX-83," 1984 AGU Ocean Sciences Meeting, New Orleans, LA. 23-27 January 1984.

P. S. Guest and K. L. Davidson, "The Drag Coefficient in the Marginal Ice Zone." 10th Annual Meeting, European Union of Geosciences, Louvain-La-Neuve, Belgium 30 July - 4 August 1984.

Title: MIZEX SUPPORT

Investigators: K. L. Davidson, Professor of Meteorology

Sponsor: Pacific Missile Test Center

Objective: To obtain from radiosonde launches, descriptions on the vertical variations of temperature, humidity, wind vector and the index of refraction in the East Greenland Sea Marginal Ice Zone

Summary: High resolution radiosonde with positioning capabilities based on Omega Navigational aid were purchased. These were provided to DMTC scientists onboard the USNS Lynch during MIZEX-84. They were launches in conjunction with launches on other ships, including the R/V Hakon Mosby from which NPS personnel performed radiosonde launches.

Title: DEPOSITION OF MARINE AEROSOLS

Investigators: K. L. Davidson, Professor of Meteorology

Sponsor: Naval Environmental Prediction Research Facility

Objective: To perform preliminary examinations based on published literature on incorporating turbulent deposition in equilibrium marine aerosol models.

Summary: Published reports by investigators at the Naval Research Laboratory, Washington, D.C. were examined relative to an inverse relationship between small size sea salt particle concentrations and wind speed. It is concluded that this inverse relationship is partially due to turbulent deposition of the small particles which have been advected into the region of measurement.

Title: ATMOSPHERIC FORCING ON OCEAN-ATMOSPHERE MIXED-LAYER PROCESSES

Investigators: K. L. Davidson, Professor of Meteorology  
G. E. Schacher, Professor of Physics

Sponsor: Office of Naval Research

Objective: The long range objective is to understand and to parameterize the dynamic and thermodynamic processes responsible for coupled changes of adjacent oceanic (OBL) and atmospheric (ABL) boundary layers. Near term objectives are to analyze an Eastern Pacific data set (MILDEX) for evaluation of an existing coupled OBL-ABL model and to design an observational experiment for the Western Atlantic (FASINEX).

Summary: A paper describing the formulated coupled Ocean-Atmosphere mixed layer model was completed and appeared in Dynamics of Atmospheres and Oceans (Davidson and Garwood, 1984). Continuous meteorological measurements of atmospheric surface layer and mixed layer properties were conducted during MILDEX (vicinity of 34 degrees North and 126 degrees West) from the R/V Acania during the period 24 October to 10 November 1983. A total of 39 radiosonde yielding temperature, humidity and vector wind profiles were launched. Two MS Theses are being completed on the combined atmosphere ocean data sets.

Publications: K. L. Davidson, C.W. Fairall, P. J. Boyle, and G.E. Schacher, 1984: "Verification of an Atmospheric Mixed-Layer Model for a Coastal Region". Journal of Climate and Applied Meteoror., 23, 617-636.  
K. L. Davidson and R. W. Garwood, Jr., 1984: "Coupled Oceanic and Atmospheric Mixed Layer Model". Dynamics of Atmospheres and Oceans, 8, 283-296.

- Conference Presentation:
- G. L. Geernaert and K. L. Davidson, "On the Behavior of the Drag Coefficient in Frontal Regions." 1984 AGU Ocean Sciences Meeting, New Orleans, LA 23-27 Jan 1984.
- G. L. Geernaert and K. L. Davidson, "Variation of the Drag Coefficient and Wind Wave Coupling in the Vicinity of a Storm Front." 10th Annual Meeting of the European Union of Geosciences, Louvain-La-Neuve, Belgium, 30 Jul-4 Aug 1984.
- Theses Directed:
- G. L. Tarbet, 1984: "Formulation of a Micro-Computer Coupled Atmosphere-Ocean Mixed Layer Model". Masters Thesis, (K. L. Davidson, advisor), December 1983.
- R. L. Hervey, 1984: "Sensitivity Analyses of a Coupled Atmosphere and Ocean Mixed Layer Model". Masters Thesis (W. R. Garwood, advisor), June 1984.
- J. Swaykos, 1984: "Evaluation of Coupled Ocean Atmosphere Mixed Layer with MILDEX Data". Masters Thesis (W. R. Garwood, advisor), December 1984.
- H. Rosner, 1985: "Evaluation of Surface Exchange Coefficients from MILDEX Ocean/Atmosphere Mixed Layer Data", Master Thesis (K. L. Davidson, advisor), March 1985.

Title: RELATING MARINE AEROSOL DISTRIBUTIONS TO  
OCEAN WHITECAPS AND SEA SPRAY

Investigators: K. L. Davidson, Professor of Meteorology  
G. E. Schacher, Professor of Physics

Sponsor: Office of Naval Research

Objective: To determine aerosol production per unit  
whitecap coverage on the basis of  
laboratory measurements and to relate open  
ocean aerosol data and whitecap coverage.

Summary: Analyses are being performed on aerosol  
data obtained in the University of Galway  
(UCG) Galway Ireland white cap simulation  
facility. These data have yielded  
information the role of turbulent  
deposition as an important removal process.  
Joint white cap and aerosol measurements  
were made with UCG scientists on board the  
R/V Hakon Mosby in the Marginal Ice Zone of  
the East Greenland Sea during June and July  
1984. These data will be added to previous  
jointly collected data for the formulation  
of a aerosol generation model. The  
production and role of large droplets in  
the surface humidity exchange are being  
emphasized in present analyses.

Publications: E. C. Monahan, C. W. Fairall, K. L.  
Davidson and P. A. Jones, "Observed  
Inter-Relationships Amongst 10 M-Elevation  
Winds, Oceanic Whitecaps and Marine  
Aerosol," Quarterly Journal of the Royal  
Meteorological Society, 109, 379-392.

C. W. Fairall and S. E. Larsen, 1984: "Dry  
Deposition, Surface Production and Dynamics  
of Aerosols in the Marine Boundary Layer".  
Atmospheric Environment, 18, 69-77.

C. W. Fairall, K. L. Davidson, and G. E.  
Schacher, 1984: "Applications of a Mixed  
Layer Model to Aerosols in the Marine  
Boundary Layer". Tellus, 36B, 203-211.

K. L. Davidson and C. W. Fairall, "Dynamics  
and Modeling of Aerosols in the Marine  
Atmospheric Boundary Layer," Proceedings,  
Whitecap Workshop, University College,  
Gallway, Ireland, September 1983,  
forthcoming.

Title: OBSERVATIONAL STUDIES OF MARINE BOUNDARY LAYER PROCESSES

Investigators: K. L. Davidson, Professor of Meteorology  
G. E. Schacher, Professor of Physics

Sponsor: Naval Air Systems Command

Objective: The long term objective is to understand through observations and modeling the turbulent and radiative processes in the Atmospheric Boundary Layer (ABL) over ocean, ice and mixed surfaces. Near term objectives are to perform analyses and interpretation on ABL properties observed in the Fram Strait Marginal Ice Zone Experiments in the summers of 1983 (MIZEX-83) and 1984 (MIZEX-84).

Summary: Evaluation and formulation improvements were performed on the atmospheric mixed layer model. New results in the evaluations were prepared for a presentation at the Nowcasting-II conference in Norrkoping, Sweden. Atmospheric surface and mixed layer measurements were made from the R/V Polarqueen in the Marginal Ice Zone of the East Greenland Sea from 1 June to 20 July 1984. The R/V Polarqueen was located within the dense ice pack most of the period. Eddy flux, dissipation and profile measurements were made from ice floes to estimate the surface fluxes of heat and momentum. A doppler SODAR was deployed most of the period to obtain vector wind and turbulent intensifies up to 500 meters.

Publications: C. W. Fairall, K. L. Davidson, and G. E. Schacher, 1984: "Applications of a Mixed Layer Model to Aerosols in the Marine Boundary Layer". Tellus, 36B, 203-211.  
K. L. Davidson, C. W. Fairall, P. J. Boyle, and G.E. Schacher, 1984: "Verification of an Atmospheric Mixed-Layer Model for a Coastal Region". Journal of Climate and Applied Meteorology, 23, 617-636.

K. L. Davidson and R. W. Garwood, Jr.,  
1984: "Coupled Oceanic and Atmospheric  
Mixed Layer Model". Dynamics of  
Atmospheres and Oceans, 8, 283-296.

P. J. Boyle, K. L. Davidson and G. E.  
Schacher, 1984: "Evaluation of an  
Integrated Mixed-Layer Model for Single  
Station Prediction in a Marine Region",  
Proc. Nowcasting-II Symposium, Norrkoping,  
Sweden, 323-327.

Conference  
Presentations:

K. L. Davidson, "Scientific Meteorology  
Questions in the Marginal Ice Zone," Second  
Alfred-Wegener-Conference on Air-Sea-Ice  
Interactions, Bremerhaven, FRG 14-18  
November 1983.

P. S. Guest and K. L. Davidson, "Drag  
Coefficients Obtained During MIZEX-84."  
AGU Ocean Sciences Meeting, 1984.

P. S. Guest and K. L. Davidson, "The Drag  
Coefficient in the Marginal Ice Zone," 10th  
Annual Meeting of the European Union of  
Geosciences, Louvain-La-Neuve, Belgium 30  
July - 4 August 1984.

P. J. Boyle, K. L. Davidson and G. E.  
Schacher, "Evaluation of an Intergrated  
Mixed Layer Model for Single Station  
Prediction in a Marine Regime." (Paper in  
proceedings, only) Nowcasting-II Symposium,  
Norrkoping, Sweden 3-7 September 1984.

Theses Directed:

G. L. Tarbet, LCDR, USN: "Formulation of a  
Micro-Computer Coupled Atmosphere-Ocean  
Mixed Layer Model," Masters Thesis,  
December 1983.

R. L. Hervey, LCDR, USN: "Sensitivity  
Analyses of a Coupled Atmosphere and Ocean  
Mixed Layer Model," Masters Thesis, (W. R.  
Garwood, advisor), June 1984.

R. D. Bisking, LT, USN: "Further  
Development and Examination of the Marine  
Atmospheric Boundary Layer Model (MABL),  
September 1984.

J. Swaykos, "Evaluation of Coupled Ocean Atmosphere Mixed Layer with MILDEX Data," Masters Thesis, (W. R. Garwood, advisor), December 1984.

J. A. McNitt, LT, USN: "Mesoscale Features and Refraction Conditions of the Arctic Marginal Ice Zone, December 1984.

M. Mohn, "SODAR Data: An Investigation of Turbulence Profiles from Shipboard" Masters Thesis, (W. Shaw, advisor), March 1985.

H. Rosner, "Evaluation of Surface Exchange Coefficients from MILDEX Ocean/Atmosphere Mixed Layer Data," Masters Thesis (K. L. Davidson, advisor), March 1985.

Title: MARINE BOUNDARY LAYER AEROSOL OPTICAL EXTINCTION

Investigators: K. L. Davidson, Professor of Meteorology  
G. E. Schacher, Professor of Physics

Sponsor: Naval Ocean Systems Center

Objective: The long term objective is to characterize atmospheric aerosol within the atmospheric boundary layer (ABL) in terms of the number density and size. These characterizations will incorporate meteorological descriptions of the ABL including the vertical profiles of temperature and humidity, the turbulent fluxes at the surface and the inversion. Near term objectives are to perform the characterization for both compact ice and open water regions of the East Greenland Sea Marginal Ice Zone in MIZEX-83 and 84.

Summary: Aerosol sensors were deployed on two ships during MIZEX-84. One ship was the R/V Polarqueen which was in the ice region and on which a OAP mounted at the 12 meter level on top of the bridge. Data were collected on the R/V Polarqueen during the last 1/2 of the period; from 5 June to 23 July. The other ship was the R/V Hakon Mosby which was in the open water off the ice edge. Measurements were from 12 June to 15 July. An ASAP, a CSAP, and an OAP were mounted on a forward mast 14 meters above the surface. The performance of the OAP was inadequate, so it was removed from the mounting in the first 2 days. The ASAP was operated successfully for 15 days after which its data were considered to be inadequate. The CSAP, from preliminary analyses, appeared to have been operating properly throughout the entire period.

Publications: C. W. Fairall and S.E. Larsen, 1984: "Dry Deposition, Surface Production and Dynamics of Aerosols in the Marine Boundary Layer". Atmospheric Environment., 18, 69-77.

C. W. Fairall, K. L. Davidson, and G. E. Schacher, 1984: "Applications of a Mixed Layer Model to Aerosols in the Marine Boundary Layer". Tellus, 36B, 203-211.

C. W. Fairall, and K. L. Davidson, 1984: "Dynamics and Modeling of Aerosols in the Marine Atmospheric Boundary Layer". Proceedings, Whitecap Workshop, University College, Galway, Ireland, September 1983, E.C. Monahan, Ed. pp 39. (Forthcoming)

Title: ATMOSPHERIC MEASUREMENTS FROM THE NOSC MAST

Investigators: K. L. Davidson, Professor of Meteorology

Sponsor: Office of Naval Research

Objective: To perform measurements of mean and turbulent wind, temperture and humidity from the Naval Ocean Systems Center (NOSC) tower off shore at San Diego, CA. during Shuttle Imaging Radar (SIR) overflights and in conjunction with tower based radar measurements.

Summary: Preparation for the measurements on the NOSC tower occurred during the last two weeks of September 1984. The first shuttle flight occurred on 5 October 1984. Airborne radar overflights occurred during the last week of September. Turbulent instruments involved were a sonic anemometer, hot film, wind fluctuation sensor a lymen-x humidity fluction sensor and platinum resistance wire temperature sensors. Tower mounting arrangements and installation were completed during the last week of September.

Title: Observational-Numerical Study of Maritime Extratropical Cyclones Using FGGE Data

Investigators: R. L. Elsberry, Professor of Meteorology  
C. H. Wash, Associate Professor of Meteorology

Sponsor: National Aeronautical and Space Administration

Objective: To better understand the development, maturation and decay of maritime extratropical cyclones using a combined observational and numerical modelling approach.

Summary: Diagnostic studies of observed and numerically simulated cases of maritime extratropical cyclones have been made. The post-frontal convective areas off the west coast of the United States can be diagnosed with a convective parameterization technique (Winninghoff and Elsberry, 1983). The semi-prognostic approach has also been used to estimate the diabatic heating in an explosive deepening cyclone (Bosse, 1984). Mass and vorticity budgets in storm-following coordinates have been calculated for a explosive cyclogenesis case over the northwestern Pacific Ocean during January 1979 (Wash and Calland, 1984) and in a polar-type cyclogenesis case (Wash and Cook, 1984). Synoptic and diagnostic studies have been made for Goddard forecasts of the North Pacific cyclogenesis event and compared with the earlier studies based on ECMWF analyses (Ebersole, 1984).

Publications:

C. H. Wash and W. Calland, "Diagnostics of Explosive Cyclogenesis During FGGE, Part I : West Pacific Cyclone of 12-16 January 1979." Monthly Weather Review (forthcoming), 1984.

C. H. Wash and W. Cook, "Diagnostics of Explosive Cyclogenesis During FGGE, Part II: North Atlantic Case of 26-27 January 1979". Monthly Weather Review (forthcoming), 1984.

F. J. Winninghoff, and R. L. Elsberry, "Some Aspects of Post-Frontal Convective Areas Along the West Coast of the United States." NPS Technical Report NPS 63-84-005, December 1983.

- Conference Presentations:
- R. L. Elsberry, "Review of Recent Research on Oceanic Cyclones." Fourth Extratropical Cyclone Project Workshop, Madison, WI, 2-4 November 1983.
- C. H. Wash, "A Diagnostic Study of FGGE Oceanic Cyclones." Fourth Extratropical Cyclone Project Workshop, Madison, WI, 2-4 November 1983.
- C. H. Wash and W. Calland, "Diagnostics of Explosive Cyclogenesis during FGGE, West Pacific Cyclone of 12-16 January 1979" Tenth Conference on Weather Forecasting and Analysis, Clearwater Beach, FL, 25-28 June 1984.
- Theses Directed:
- T. E. Bosse, "An Evaluation of the NOGAPS Diabatic Parameterization and the Contribution of Diabatic Heating in a Case of Explosive Maritime Cyclogenesis." M.S. Thesis, June 1984.
- K. Ebersole, "Diagnostic Study of NASA Model Forecasts of Explosive Cyclogenesis." M.S. Thesis, September 1984.

Title: Tropical Cyclone Studies

Investigator: R. L. Elsberry, Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: To improve numerical predictions of tropical and extratropical circulation systems in which convective clouds play an important role.

Summary: The feasibility of applying statistical post-processing techniques to reduce the systematic bias in Southern Hemispheric tropical cyclone track predictions has been demonstrated (Peak and Elsberry, 1984a). Official and objective forecast aids for tropical cyclone tracks in the northwest Pacific during 1979-83 have been evaluated in terms of cross-track and along-track components relative to a persistence forecast (Elsberry, Lage and Peak, 1984; Elsberry and Peak, 1984). Empirical orthogonal function representations of the surrounding height fields have been shown to be useful in predicting tropical cyclone turning and acceleration (Peak and Elsberry, 1984 b and c). A study of the convective parameterization in post-frontal convective clusters was completed (Winninghoff and Elsberry, 1983). Examples of how amplification of midlatitude planetary waves 3-6 days prior to winter monsoon cold surges is associated with the intensification of the surge have been presented (Shaffer, Chang, and Elsherry, 1984).

Publications:

R. L. Elsberry and J. E. Peak, "An Evaluation of Tropical Cyclone Forecast Aids Based on Cross-Track and Along-Track Components". In progress, 1984.

J. E. Peak and R. L. Elsberry, "Dynamical-Statistical Model Forecasts of Southern Hemisphere Tropical Cyclones". Monthly Weather Review, 112, 717-724, 1984a.

J. E. Peak and R. L. Elsberry, "Prediction of Tropical Cyclone Turning and Acceleration Using Empirical Orthogonal Function Representations." Proceedings 15th Technical Conference on Hurricanes and Tropical Meteorology, Miami, American Meteorological Society (Boston), pp. 45-50, 1984b.

J. E. Peak and R. L. Elsberry, "Prediction of Tropical Cyclone Turning and Acceleration Using Empirical Orthogonal Function Representations." In progress, 1984c.

A. R. Shaffer, C.-P. Chang and R. L. Elsberry,  
"Long-Wave Forcing of Equatorward Penetrating Winter  
Monsoon Cold Surges." Proceedings of 15th Technical  
Conference on Hurricanes and Tropical Meteorology,  
Miami, FL, American Meteorological Society (Boston),  
427-432, 1984.

F. J. Winninghoff and R. L. Elsberry, "Some Aspects of  
Post-Frontal Convective Areas Along the West Coast  
of the United States." Technical report NPS 63-84-  
005, 38 pp. December 1983.

Conference  
Presentation:

R. L. Elsberry, T. D. Lage and J. E. Peak, "Two  
Evaluations of the Operational Forecast Guidance at  
JTWC." 15th Technical Conference on Hurricanes and  
Tropical Meteorology, Miami, FL, 9-13 January 1984.

Title: Air-Sea Interaction Studies

Investigator: R. L. Elsberry, Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: To improve medium-range atmospheric forecasts through coupled atmosphere-ocean model studies.

Summary: The six-layer NOGAPS model forecasts to 10 days with a fixed sea-surface temperature field are compared with hindcasts in which the observed sea-surface temperature each 12 hours are imposed. The first case study from Spring 1983 has been completed (Ranelli, 1984; Ranelli, Sandgathe, and Elsberry, 1983; Ranelli, et al., 1984). Two additional cases during Fall 1983 and Spring 1984 have been studied (Rovero, 1984). A study of the short-term response predicted by an oceanic mixed layer model that is forced by a global sector atmospheric model has been completed (Elsberry, Sandgathe and Winninghoff, 1984).

Publications: R. L. Elsberry, S. A. Sandgathe and F. J. Winninghoff, "Short-Term Oceanic Response Predicted by a Mixed Layer Model Forced with a Sector Atmospheric Model". Journal Physical Oceanography, 14, 79-91, 1984.

P. H. Ranelli, R. L. Elsberry, Chi-Sann Liou, and S. A. Sandgathe, "Effects of Varying Sea-Surface Temperature on 10-Day Atmospheric Model Forecasts." Proceedings of 16th International Liege Colloquium on Ocean Hydrodynamics, 29 pp. plus 13 figures, forthcoming.

Conference Presentations: P. H. Ranelli, S. A. Sandgathe and R. L. Elsberry, "Response of an Atmospheric Prediction Model to Time-Dependent Sea-Surface Temperatures." AGU Fall Meeting, San Francisco, CA, December 1983, Abstract in EOS, 64, No. 45, 671.

Theses Directed: P. H. Ranelli, "Response of an Atmospheric Prediction Model to Time-Dependent Sea-Surface Temperatures". M.S. Thesis, March 1984.

P. J. Rovero, "Simulation of Synchronously Coupled Atmosphere-Ocean Prediction Model." M.S. Thesis, September 1984.

Title: Oceanic Response to Atmospheric Forcing

Investigator: R. L. Elsberry, Professor of Meteorology

Sponsor: Office of Naval Research

Objective: To understand and predict the response of the upper ocean to atmospheric forcing.

Summary: The primary thrust in the research has been in ocean response to hurricane forcing (Shay, 1983). A manuscript by Shay and Elsberry (1984) on the analysis of the first set of NAVOCEANO current measurements in Hurricane Frederic has been submitted. A numerical study of the short-term ocean response to atmospheric forcing has been published (Elsberry, Sandgathe and Winninghoff, 1984). Elsberry and Adamec (1983) and Adamec and Elsberry (1984a) describe the sensitivity of the ocean model to variations in the magnitude of the atmospheric forcing. These tests demonstrate the importance of accurate wind speed specifications for ocean modelling. Adamec and Elsberry (1984b) demonstrate the effect of using averaged atmospheric forcing for ocean prediction.

Publications:

D. Adamec, and R. L. Elsberry, "Sensitivity of Mixed Layer Predictions at Ocean Station Papa to Atmospheric Forcing Parameters." Journal Physical Oceanography, 14, 769-780, 1984a.

D. Adamec and R. L. Elsberry, "The Effect of Mean Atmospheric Forcing in an Ocean Mixed-Layer Model." Journal Physical Oceanography (forthcoming) 1984b.

R. L. Elsberry and D. Adamec, "Sensitivity Studies with an Upper Ocean Prediction Model". In Predictability of Fluid Motions (La Jolla Institute 1983) edited by G. Hollaway and B.J. West, American Institute of Physics, New York, 1983.

R. L. Elsberry, S. A. Sandgathe and F. J. Winninghoff, "Short-Term Oceanic Response Predicted by a Mixed Layer Model Forced with a Sector Atmospheric Model." Journal Physical Oceanography, 14, 79-91, 1984.

L. K. Shay and R. L. Elsberry, "Ocean Current Response to Hurricane Frederic". 27 pp plus 15 figures

Conference

Presentations:

L. K. Shay and R. L. Elsberry, "Observations of Inertio-Gravity Waves in the Wake of Hurricane Frederic" American Geophysical Union Fall Meeting, San Francisco, CA, 5-9 Dec 1983, Abstract in EOS, 64, No. 45, 739.

Thesis Directed:

L. K. Shay, "Observations of Inertio-Gravity Waves in the Wake of Hurricane Frederic". M.S. Thesis, December 1983.

Title: Modelling Upper Ocean Thermal Structure

Investigators: R. L. Elsberry, Professor of Meteorology, and  
R. W. Garwood, Jr., Associate Professor of  
Oceanography

Sponsor: Naval Ocean Research and Development  
Activity

Objective: Application of a one-dimensional oceanic boundary  
layer model for prediction of upper ocean thermal  
structure.

Summary: The history of each significant ocean temperature  
anomaly found in the North Pacific Experiment  
TRANSPAC monthly analysis during 1976-1979 has been  
traced (Elsberry, 1984). One-dimensional model  
hindcasts of selected cold anomalies during this  
period have been compared with the analyses  
(Stringer, Elsberry and Gallacher, 1983; Stringer,  
1983). Similar hindcast studies of warm anomalies  
are in progress.

Publication: R. L. Elsberry, "A Synoptic Case Study Analysis  
of the Ocean Temperature Anomalies in the Central  
Pacific Region during 1976-79." NPS Technical  
Report, NPS-63-84-003, 75 pp., January 1984.

Conference  
Presentation: G. L. Stringer, R. L. Elsberry and P. C. Gallacher,  
"Some Examples of Cold Anomaly Development and  
Evolution in the Central North Pacific." American  
Geophysical Union Fall Meeting, San Francisco,  
CA, 5-9 Dec 1983. Abstract in EOS, 64, No. 45, 737.

Thesis Directed: G. L. Stringer, "One Dimensional Model Hindcasts  
of Cold Anomalies in the North Pacific Ocean."  
M.S. Thesis, December 1983.

Title: Oceanic Current System Response to Atmospheric Forcing

Investigator: R. L. Elsberry, Professor of Meteorology

Sponsor: Office of Naval Research

Objective: To simulate the effect of strong atmospheric cooling events on the location and intensity of an oceanic current system such as the Gulf Stream.

Summary: Sensitivity studies of ocean thermal structure predictions to various averaging periods of the atmospheric forcing have been published (Adamec and Elsberry, 1984a). The effect of a cross-stream gradient in cooling has been simulated in a two-dimensional model of the Gulf Stream (Adamec and Elsberry, 1984b). Different latitudinal deflections are simulated if convective exchange of momentum is included or excluded. Three-dimensional simulations are in progress.

Publications: D. Adamec and R. L. Elsberry, "The Effect of Mean Atmospheric Forcing in an Ocean Mixed-Layer Model." Journal Physical Oceanography (forthcoming) 1984a.  
D. Adamec and R. L. Elsberry, "Response of an Intense Oceanic Current System to Cross-Stream Cooling Events." Journal Physical Oceanography (forthcoming), 1984b.

Title: Large-Scale Atmosphere-Ocean Coupling

Investigators: Robert L. Haney, Professor of Meteorology and  
Mary A. Rennick, Adjunct Research Professor of  
Meteorology

Sponsor: National Science Foundation

Objective: To study oceanic and atmospheric variability due to  
air-sea interaction in the equatorial region using  
coupled ocean-atmosphere models.

Summary: The linear stability of coupled shallow water models of  
the ocean and atmosphere have been investigated  
analytically. We show that the growth rates, phase  
speeds and meridional structures of disturbances in the  
equatorial region depend strongly on the form of the  
atmosphere-ocean coupling and on the particular  
characteristics of the atmospheric basic state about  
which the models are linearized. This sensitivity of  
the behavior of the coupled ocean-atmosphere system is  
also found in nonlinear numerical models as well.  
Present efforts are directed at studying possible  
mechanisms for the onset of the El Nino-Southern  
Oscillation phenomenon as part of the U.S.TOGA  
(Tropical Ocean Global Atmosphere) program.

Publications:

M. A. Rennick and R. L. Haney, "Stable and Unstable  
Air-Sea Interactions in the Equatorial Region."  
Journal of Atmospheric Science, (submitted).

M. A. Rennick, "Atmosphere-Ocean Coupling during a Warm  
Event in the Equatorial Pacific", Proceedings of Liege  
Colloquium on Large-Scale Air-Sea Interaction, J. C.  
Vihoul, Editor.

Title: Numerical Modeling of Large Scale Ocean Variability

Investigator: Robert L. Haney, Professor of Meteorology

Sponsor: Office of Naval Research

Objective: To study mechanisms for large scale variability in the North Pacific Ocean by means of controlled numerical model experiments.

Summary: A multi-level primitive equation ocean circulation model with surface layer physics has been used to study the interannual variability of sea surface temperatures (SST) and the sub-surface thermal structure in the central North Pacific Ocean. Results from a ten-year model hindcast using observed synoptic winds have been analyzed and compared with observations. An analysis of model generated SST anomalies in comparison with observations suggests that observed SST anomalies in middle and lower latitudes are primarily due to anomalies in the surface heat flux. Processes related to the winds alone, such as Ekman pumping, Ekman advection and vertical mixing contribute to SST anomaly generation but are generally too weak to account for the observation.

Publications:

R. L. Haney, B. H. Houtman and W. H. Little, "The Relationship Between Wind and Sea Surface Temperature Anomalies in the Midlatitude North Pacific Ocean," Atmosphere-Ocean, 21 (2), 168-186, 1983.

R. L. Haney, Comment on "Seasonality in the Associations Between Surface Temperatures Over the United States and the North Pacific Ocean," Monthly Weather Review, 112 (4), 868-870.

Title: Operational Weather Forecasting -- Antarctica

Investigator: R. J. Renard, Professor, and  
W. J. Thompson, Meteorologist, Department of Meteorology

Sponsor: Naval Support Force Antarctica

Objective: To improve the operational weather forecasting capability in Antarctica, with emphasis on the area surrounding the Naval Support Force Antarctica base at McMurdo.

Summary: In FY 1984, an updated climatology of low visibility at McMurdo and Williams Field, Antarctica due to blowing snow and fog, and substratified by various related parameters (e.g., wind, temperature, dewpoint, time of day), was completed. Automatic Weather Station (AWS) data from the western Ross Ice Shelf area continue to be collected and have been used to further develop climatological fields of wind, temperature and pressure in the area. A study of the 1980-81 AWS data from the Ross Ice Shelf area has been completed. Statistical correlations (with and without lag) of events at the AWS and McMurdo have been established for use in forecasting weather at McMurdo.

Publications: R. J. Renard and C. G. Souders, "The visibility climatology of McMurdo/Williams Field, Antarctica" in Proceedings of the 10th Conference on Weather Forecasting and Analysis, Am. Met. Soc., Boston, MA, 1984.

Conference Presentations: R. J. Renard, "Climatology and Weather Forecasting for the Ross Ice Shelf Area of Antarctica, Using AWS Data and Standard Observations", NSF Antarctic Automatic Weather Station Conference, NOAA Building, Boulder, CO, 22 March 1984.

R. J. Renard and C.G. Souders, "The Visibility Climatology of McMurdo/Williams Field, Antarctica," American Meteorological Society, 10th Conference on Weather Forecasting and Analysis, Clearwater Beach, FL, 25-29 June 1984.

Theses directed: S. P. Hervey, "A Study of Antarctic Remote-Site Automatic Weather Station Data (1980-1981)", Masters Thesis, March 1984.

C. G. Souders, "The Visibility Climatology of McMurdo Sound/Williams Field, Antarctica", Masters Thesis, March 1984.

Title: Air Flow over Large Scale Topography

Investigators: M. A. Rennick, Adjunct Professor of Meteorology and  
R. T. Williams, Professor of Meteorology

Sponsor: National Science Foundation

Objective: To utilize observational results from ALPEX with theoretical and numerical studies to investigate the interaction between air flow and large scale topography.

Summary: The formation of cyclones in the lee of a long mountain range was studied with analytic and numerical models and the principal mechanism was isolated.

Publications: J. L. Hayes, R. T. Williams and M. A. Rennick,  
"Numerical Study of Lee Cyclogenesis", Zbornik Meteoroloskih i Hidroloskih Radova, 10, 80-83.

Conference Presentation: J. L. Hayes, R. T. Williams and M. A. Rennick,  
"Numerical Study of Lee Cyclogenesis", International Conference for Alpine Meteorology, Opatkga, Yugoslavia, 25-29 September 1984.

Title: Radiosonde Evaluation and Support

Investigator: W. J. Shaw, Assistant Professor of Meteorology

Sponsor: Pacific Missile Test Center

Objective: To obtain high-resolution temperature, humidity, refractive index, and wind vector profiles during the Marginal Ice Zone Experiment (MIZEX-84).

Summary: Radiosondes with position-finding capabilities based on the Omega navigational aid system and associated supplies were purchased. These were launched from the USNS Lynch by PMTC scientists during MIZEX-84 in conjunction with launches from other ships, including the R/V Hakon Mosby from which NPS personnel performed radiosonde launches. I cooperated with PMTC scientists in testing and modifying the system prior to use in MIZEX.

Title: Investigation of the Structure and Evolution of the Coastal ABL using an Acoustic Doppler Sodar System

Investigator: W. J. Shaw, Assistant Professor of Meteorology

Sponsor: NPS Foundation Research Program

Objective: The objective of this effort was to initiate surface-based remote sensing capability for the atmospheric boundary layer which will ultimately yield insight into: the relationship between inversion wind shear and ABL small-scale structure and entrainment energetics; ABL structure resulting from inhomogeneities of the coastal region; and the relationship between the structure of the coastal ABL and larger-scale weather systems. The program is continuing in FY85.

Summary: Software was developed that provides for the transfer of Sodar data from the microprocessor which drives the data acquisition system to the NPS IBM 3033 mainframe. This allows for complete and sophisticated analysis of the data. The Sodar system was deployed at Pt. Pinos, CA--a location which gives exposure both to an essentially undisturbed marine ABL with westerly flow and to a boundary layer influenced by coastal effects when the wind is weak or flow is from other directions. Measurements have been made of the mean wind profiles and small-scale turbulence intensity ( $C_T^2$ ) throughout the depth of the ABL.

Title: GOES Satellite Data Analysis for Weather Analysis and Forecasting

Investigator: C. H. Wash, Associate Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: Implement algorithms to analyze GOES visual, infrared and other channel data to produce specification of hazardous surface weather for naval operations (presence of precipitation, precipitation intensity, low visibilities and ceilings) in silent areas between conventional observations using the SPADS system.

Summary: Satellite cloud and precipitation estimation program evaluation was completed using GOES-E data over the eastern coast of the United States. Collocated GOES and surface data sets are being used to further develop cloud mapping techniques. Surface data were added to the estimation program.

Conference Presentation: Wash, C., L. Chou, C. Nelson, C. Moren and L. Spray, "Satellite Cloud and Precipitation Analysis Using Interactive Computer System". Preprints of Conference on Satellite/Remote Sensing Applications, Clearwater Beach, FL, 25-29 June 1984, 155-159.

Wash, C., L. Chou, and L. Spray, "Geostationary Satellite Cloud and Precipitation Analysis Using an Interactive Computer System" Proceedings of Nowcasting II Symposium, Novikopping, Sweden, 3-7 September 1984.

Theses directed: L. Paul, "A Study of Precipitation Occurrence Using Visual and Infrared Satellite Data", M.S., December 1983.  
C. Moren, "An Evaluation of an Automated Cloud Analysis Program Using SPADS", M.S., March 1984.  
N. Wyse, "Combined Satellite and Surface Data in Automated Cloud and Precipitation Analyses", M.S., June 1984.  
D. Rust, "Satellite Specification of Precipitation and Low Visibility Regions", M.S., September 1984.

Title: Numerical Modeling of Unique Atmospheric Phenomena

Investigators: R. T. Williams, Professor of Meteorology  
M. A. Rennick, Adjunct Professor of Meteorology and  
C.-P. Chang, Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: Develop and test better numerical techniques for  
use in Navy weather forecasting models.

Summary: The upper boundary condition in the NEPRF spectral  
model was modified and tested. The new UCLA finite  
difference scheme was compared with the modified NEPRF  
spectral model in experiments with topography and  
cyclogenesis. Non-geostrophic solutions for lee-  
cyclogenesis were obtained with the use of the  
Hoskins coordinate transformation. The numerical  
experiments with monsoon fronts which simulated  
the observed low level jet were analyzed with  
various diagnostics. Synoptic studies demonstrated  
the importance of the interaction between inter-  
mediate scale and planetary waves in the triggering  
of cold surges. The behavior of planetary waves as  
a function of heating and initial conditions was  
studied with the NEPRF Spectral model.

Publications: J. L. Hayes, R. T. Williams and M. A. Rennick,  
"Numerical Study of Lee Cyclogenesis", Zobrink,  
Meteorologicheskii i hidrologicheskii Radova, 10, 80-83.

Conference  
Presentation: A. Shaffer, C.-P. Chang and R. L. Elsherry,  
"Long-Wave Forcing of Equatorial Penetrating Winter  
Monsoon Cold Surges," 15th Technical Conference on  
Hurricanes and Tropical Meteorology, American  
Meteorological Society, Miami, FL, 9-13 January 1984.

Title: Development of Finite Element Prediction Model

Investigators: R. T. Williams, Professor of Meteorology  
A. L. Schoenstadt, Associate Professor of Mathematics  
R. E. Newton, Professor of Mechanical Engineering

Sponsor: Naval Air Systems Command

Objective: To develop and test a finite element atmospheric prediction model.

Summary: The Canadian baroclinic finite element program was converted to run on the NPS IBM 3033. Cyclic boundary conditions were then installed in the barotropic version of this code. The required elliptic solvers were developed for variable boundary conditions.

Title: Regional Synoptic Forecasting: Southern African Continent and Surrounding Ocean Areas

Investigators: F. R. Williams, Adjunct Professor, and R. J. Renard, Professor, Department of Meteorology.

Sponsor: Naval Air Systems Command

Objective: To assess the status of and make improvements on the analysis and forecasting of weather parameters important to air/sea operations over the Southern African Continent and surrounding South Atlantic/Indian Ocean areas (approximately 5°N-45°S, 60°E-0°).

Summary: A Weather Forecaster's Handbook for the Southern African Continent and Atlantic/Indian Ocean Transit is nearing completion. The digest is intended especially for use by the Navy's Oceanography Officers and their staffs. It covers the area of the Southern African Continent and surrounding South Atlantic/Indian Ocean areas (approximately 5N-45S lat, 60E-0 long). Major sections include general climatology and forecasting aspects of Southern Hemisphere weather, forecasting sections on Southern Africa, Malagasy Republic, Mozambique, Kenya and Tanzania; tropical cyclone forecasting to include the areas of Mascarene and Seychelles Islands; and ocean weather and coastal geographic influences. Completion of the publication is expected in FY 85.

Publications: F. R. Williams, R. J. Renard, R. D. Tomkins, G. H. Jung, and R. Picard, "Forecaster's Handbook for the Southern African Continent and Atlantic/Indian Ocean Transit". NEPRF Technical Report, forthcoming in 1985.

Thesis Directed: R. D. Tomkins, "Significant Weather Systems Over the Southern African Continent and Surrounding Oceans". Masters Thesis, March 1984.

**DEPARTMENT  
OF  
AERONAUTICS**

## DEPARTMENT OF AERONAUTICS

During the reporting period, Aeronautics faculty have been active in the following major research areas:

### AIRCRAFT COMBAT SURVIVABILITY

Professor Ball has continued his investigations of aircraft survivability enhancement especially in the areas of flight control design and the effect of component redundancy on the probability of aircraft survival after multiple hits. He also completed a book on aircraft combat survivability, to be published by the American Institute of Aeronautics and Astronautics.

### SATELLITE VULNERABILITY TO HIGH ENERGY LASERS

Professor Fuhs has been studying the vulnerability of a specific USN satellite to soviet lasers.

### OBLIQUE WING TECHNOLOGY

Professor Fuhs has been investigating the suitability of oblique wing technology to USN/USMC aircraft missions using NASA Ames computer codes.

### ADVANCED INDIRECT FIRE SUPPORT TECHNOLOGY

Professor Fuhs examined the applicability of U.S. Army cannon-launched, ramjet-propelled guided projectiles for Navy missions.

### UNDERWATER SHAPED CHARGES

Professor Fuhs is investigating the characteristics of metal-steam combustion for the purpose of predicting the behavior of metal jets from shaped charges fired underwater.

### SPACECRAFT CONTAMINATION FROM LASER EXHAUST

Professor Collins performed flow field measurements of a mechanically existed subsonic jet using a two-component laser-doppler anenometer.

#### INSPECTION OF STEAM LINES

Professor Miller investigated techniques for the evaluation of thermal losses in underground steamlines.

#### ELECTROHYDRODYNAMIC FUEL INJECTION CONTROL

Professors Millers and Biblarz continued a program to evaluate the merits of electrohydrodynamically modulated fuel injection for gas turbine combustors.

#### GAS TURBINE COMBUSTOR EMISSIONS

Professor Netzer conducted an experimental investigation of the effects of solid propellant properties and motor operating conditions on metallized particulates within the combustor and exhaust nozzle.

#### METALLIZED SOLID FUEL RAMJET COMBUSTION

Professor Netzer conducted fundamental experimental and analytical studies to enhance the understanding of the combustion behavior of ramjets which utilize large mass fractions of metals within the solid fuel.

Title: Aircraft Combat Survivability Textbook  
Investigator: R. E. Ball, Professor of Aeronautics  
Sponsor: Joint Technical Coordinating Group on Aircraft  
Survivability (JTCG/AS)  
Summary: The textbook was completed this fiscal year.  
It has been submitted for review by the sponsor,  
for public release. Publication date unknown.

Title: LDA Flow Field Measurements

Investigator: D. J. Collins, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To measure complex flow fields using laser-doppler anemometry.

Summary: Measurements were made of the flow field generated by a mechanically excited subsonic jet using a two component laser-doppler anemometer.

Publications: D. J. Collins, W. H. Harch, M. F. Platzer,  
"Measurements of Vane-Excited Jets", Proceedings  
of the 2nd International Symposium on Applications  
of Laser Anemometry to Fluid Mechanics, 2-4 July  
1984, Lisbon, Portugal

Title: Satellite Vulnerability to High Energy Lasers

Investigator: A. E. Fuhs, Professor of Aeronautics

Sponsor: Naval Electronics Systems Command

Objective: The project has two objectives. First, a specific USN satellite will be studied for vulnerability to specific Soviet lasers. Second, a range of lasers, basing modes, and satellites will be investigated.

Summary: The research is a multi-year effort which was initiated in FY83. In FY84, time was spent gathering background information. A computer code Ground Up To Space (GUTS) propagation through the atmosphere has been modified for use on the NPS computer.

Thesis Directed:

C. E. Jewett, "Satellite Vulnerability to Ground Based High Energy Lasers", Master's Thesis, June 1984.

H. F. Sheehy, "Satellite Vulnerability to Ground Based Iodine Laser", Master's Thesis, June 1984.

A. Macy, "Satellite Vulnerability to Ground Based CO and CO<sub>2</sub> Lasers", Master's Thesis, June 1984.

J. Morrow, "Ground Up to Space Computer Code", Master's Thesis, June 1984.

R. F. Ziska, "Satellite Vulnerability to Laser Attack", Master's Thesis, September 1984.

Title: Application of Oblique Wing to Naval Missions

Investigator: A. E. Fuhs, Professor of Aeronautics

Sponsor: NASA Ames Research Center

Objective: The objective is to apply oblique wing technology to selected USN/USMC aircraft missions. Aircraft will be designed using a NASA Ames computer code which is known as Aircraft Synthesis Program.

Summary: Oblique wing technology offers considerable advantages to aircraft which must cruise transsonically and have long loiter time. Aircraft with oblique wings may have supersonic dash capability. The project spans two fiscal years.

Thesis Directed: R. L. Meng, "Oblique Wing Applied to Naval Missions", Master's Thesis, March 1984.

Title: Application of Advanced Indirect Fire Support  
(AIFS) Technology to Naval Missions

Investigator: A. E. Fuhs, Professor of Aeronautics

Sponsor: Defense Advanced Research Project Agency

Objective: Under AIFS sponsorship, several contractors are investigating cannon-launched, ramjet-propelled guided projectiles for U. S. Army/USMC 155mm cannons. The work at NPS is to examine Navy missions for which the technology is applicable.

Thesis Directed: D. S. Davidson, "Application of GRIN Lens to Missile Sensors", Master's Thesis, September 1984.

Title: Spacecraft Contamination from Laser Exhaust

Investigator: A. E. Fuhs, Professor of Aeronautics

Sponsor: Defense Advanced Research Projects Agency

Objective: To determine the flux of backscattered molecules when an open-cycle laser is fired from a spacecraft.

Summary: The project was initiated in late FY82. During FY84, a Monte Carlo computer program was written by Dr. S. Abramovich who was at the Naval Postgraduate School on sabbatical from Israel. A module of the program was an axisymmetric method of characteristics program.

Publications: S. Abramovich, "Monte Carlo Rarefied Gas Dynamics Computer Code", Technical Report - NPS 67-84-001CR

Title: Electrohydrodynamic Control of Fuel  
Injection in Gas Turbine Combustors

Investigator: J. A. Miller, Associate Professor of Aeronautics  
and O. Biblarz, Associate Professor of  
Aeronautics

Sponsor: Naval Air Systems Command

Objective: A program is in progress to evaluate the merits of electrohydrodynamically - modulated fuel injection for gas turbine combustors. Fuel injection spray characteristics are being studied with an optical technique and the effects on combustion are being evaluated from measurements of combustion product temperatures. The goal of this program is to evolve practical means of using electrostatic elements within the combustion chamber to control fuel spray characteristics and thus optimize combustion efficiency for a variety of gas turbine fuels. The electrical probes considered are rugged and may be inserted with minimum penalty during engine overhaul.

Summary: A T-56 aircraft injector has been employed in the spray characteristics investigation and a T-56 injector and combustion-can liner have been incorporated into a combustion apparatus. Preliminary results indicate that a centerline electrode charged with voltages typical of spark plugs, ( 30kV), is capable of producing large charges in fuel spray characteristics. It has been possible to burn a non-design fuel such as diesel in the combustors. Some practical difficulties in maintaining electrode voltage in the presence of ionizing flame fronts has been encountered and a development program to overcome this difficulty is underway. Additionally, studies are being conducted to better understand the effects of electrostatic fields on spray characteristic modification and the subsequent implications to the burning process and combustion efficiency. Development of a spray characteristic diagnostic instrument for the determination of Sauter Mean Diameter by optical techniques employing a variable focal length element is expected to lead to a second patent application. A patent has been granted on the fundamental concept.

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A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH  
PROGRAM(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA

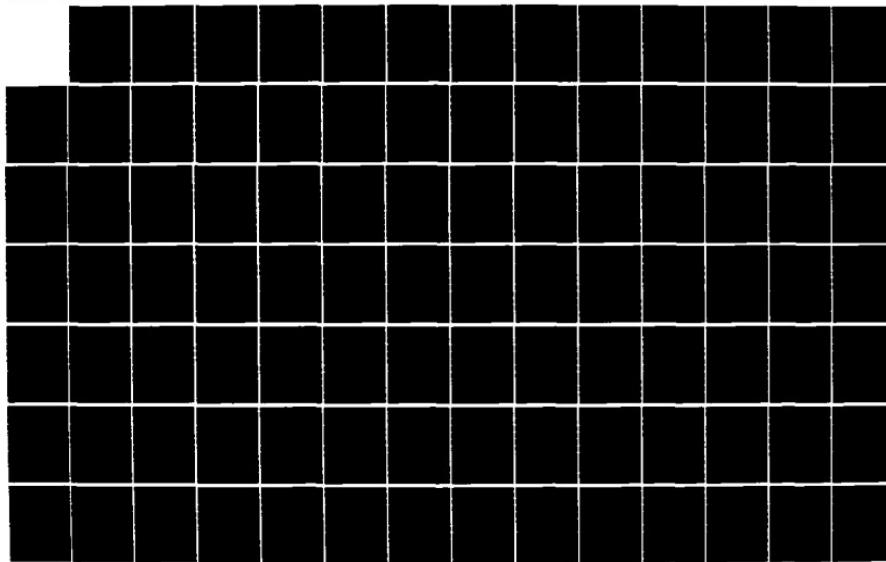
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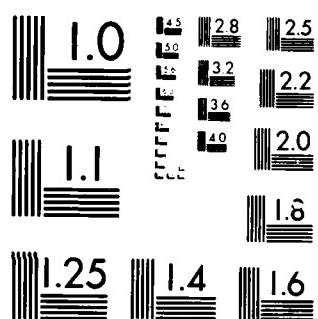
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**Thesis Directed:** M. W. Maning, "Study of Electrostatic Modulation of Fuel Sprays to Enhance Combustion Performance in Aviation Gas Turbine", AE Thesis

J. Powers, "Particle Sizing from Forward Scattered Light," Master's Thesis

**Publications:** J. A. Miller, O. Biblarz, A. Zajdman, W. W. Manning and J. A. Maurooudis, "The Effect of Electrostatic Spray Modification on Combustion in Gas Turbines," ASME Paper No. 84-GT-102, American Society of Mechanical Engineers, New York, 1984, Archive journal manuscript in preparation.

**Conference Presentation:** J. A. Miller, Effect of Electrostatic Spray Modification on Combustion in Gas Turbines, presented at the 29th International Gas Turbine Conference, Amsterdam, June 1984.

**Patent Applications:** O. Biblarz, J. A. Miller, R. J. Laib, "Electrohydrodynamic Control of Fuel Injection in Gas Turbines," Patent No. 4,439,980.

A patent application covering a new optical instrument for the determination of particulate size in two phase flows is in preparation.

Title: Inspection Techniques for Underground Steam Lines

Investigator: J. A. Miller, Associate Professor of Aeronautics

Sponsor: Naval Civil Engineering Laboratories

Objective: Investigate and develop methods and techniques to enable activity level public works departments inspect, maintain and plan for renewal of steam distributions systems to minimize energy consumption in such systems.

Summary: A self-contained field procedure for the location of leaks in the protective shell of direct burial steam distribution conduits has been developed, tested and given over to the Naval Energy and Environmental Services Activity, (NEESA), for integration into the Navy's maintenance system. Techniques for the direct evaluation of thermal losses from distribution conduits have been developed and computer techniques for the overall energy management and detection of faults are now being evaluated. Several users manuals and an overall summary of thermal losses in the Navy's steam distribution have been completed and, as an accidental byproduct, a maintenance scheme for minimum life cost strategy for steam traps has evolved and been submitted as a Beneficial Suggestion. Estimated savings to the Navy are 15 million dollars per year over current practice.

Publications: J. A. Miller, "The Location of Leaks in the Sheath of Pressure Testable Direct Burial Steam Distribution Conduits," Naval Field Service Manual, NCEL, Port Hueneme, CA, 1984.

J. A. Miller, J. C. King and C. G. Winterheimen, "Investigation of Navy-wide Steam Distribution Energy Losses," NCEL Report, NCEL, Port Hueneme, CA, 1984.

J. A. Miller, "A Minimum Life Cost Strategy for Steam Trap Maintenance," NCEL Report, NCEL, Port Hueneme, CA, 1984.

J. A. Miller, "A Minimum Life Cost Strategy for  
Steam Trap Maintenance," Paper No. CH-85-10-No. 5  
Accepted for presentation at the ASHRAE Meeting,  
January 1985 and publication in Transactions of  
the American Society of Heating, Refrigeration and  
Airconditioning Engineers Conference Presentation:  
See item 4 "Publications".

Title: Metallized Solid Fuel Ramjet Combustion

Investigators: D. W. Netzer, Professor of Aeronautics and  
Alon Gany, Visiting Research Contractor

Sponsor: National Research Council/NPS Foundation

Objective: Conduct fundamental, experimental and analytical studies to enhance the understanding of the combustion behavior of ramjets that utilize large mass fractions of metals within the solid fuel.

Summary: Experimental studies have been made using a small two-dimensional combustor to obtain high-speed motion pictures of the metallic combustion process. Particulate surface agglomeration processes and trajectories through the boundary layer have been studied as a function of operating pressure and type of metal in the fuel.

Publications: A. Gany and D. W. Netzer, "Fuel Performance Evaluation for the Solid-Fueled Ramjet," Naval Postgraduate School Technical Report, NPS67-84-012, October 1984.

Title: Solid Propellant Combustion

Investigator: D. W. Netzer, Professor of Aeronautics, and  
J. Powers, Professor of Electrical and Computer  
Engineering

Sponsor: Air Force Rocket Propulsion Laboratory

Objective: To conduct an experimental investigation of the effects of solid propellant properties and motor operating conditions on metallized particulates within the combustor and exhaust nozzle. The techniques investigated are: high speed motion pictures, holography, light scattering, and scanning electron microscopy. Additionally, techniques of automatic data reduction from holograms of the particulates were investigated.

Summary: In automatic data reduction, the overlying speckle is observed to limit resolution of the particles. Analysis was performed to identify the source of the limiting speckle size and to modify the recording and reconstruction geometry of the hologram to reduce speckle to a minimum. A Quantimet 720 image processing system was obtained and operator training on obtaining particle size histograms was done using photographs of hologram reconstructions. This system has also been used to examine images from holograms and to measure the speckle. The hologram has been mounted on a digitally controlled stage to provide three-dimensional precision motion of the reconstruction volume.

The high speed motion picture techniques which used monochromatic and intense white-light illumination have resulted in excellent quality films of burning propellant strands in which the flame envelopes surrounding the burning particles are practically eliminated.

An apparatus has been developed which uses dual-beam measurement of diffractively scattered light to determine the change in  $D_{32}$  across an exhaust nozzle. The apparatus and data reduction techniques have been validated using precision spherical glass beads, and aluminum oxide powder. Initial tests have resulted in measurements of realistic in-motor particle size. Final validation is currently being made using collected exhaust particulates.

A small two-dimensional motor has been used to obtain good quality holograms of the particulate in a cross-flow environment within specified ranges of operating pressure (<900 psia) and metal content (<10% aluminum).

Publications:

J. Powers, D. W. Netzer, et al., "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," Technical Report AFRL TR-84-014, Air Force Rocket Propulsion Laboratory, Edwards Air Force Base, 1984, 94 pages.

D. W. Netzer, J. Powers, et al., "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," Proceedings of the 20th JANNAF Combustion Meeting, (Chemical Propulsion Information Agency, Publication No. 883, Johns Hopkins University Applied Physics Laboratory, Laurel, MD, 1984), pp. 319-332.

Conference:

D. W. Netzer, J. Powers and others, "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," 20th JANNAF Combustion Meeting, Monterey, CA, 17-20 October 1983.

D. W. Netzer, J. Powers and others, "An Investigation of Experimental Techniques for Obtaining Particulate Behavior in Metallized Solid Propellant Combustion," 1984 AFOSR/AFRL Rocket Propulsion Research Meeting, Lancaster, CA, 12-15 March 1984.

Theses Directed:

L. Klooster, "Image Processing of Solid Propellant Combustion Holograms Using the Quatimet 720," Master's Thesis, December 1983.

P. J. Mellin, "Holographic Investigation of Solid Propellant Combustion Particles," Master's Thesis, September 1984.

R. K. Harris, "An Apparatus for Sizing Particulate Matter in Solid Rocket Motors," Master's Thesis, June 1984.

A. Kertadijaya, "Particulate Size Changes Across A Solid Propellant Rocket Exhaust Nozzle," Master's Thesis, current.

Title: Solid Fuel Ramjet Combustion

Investigator: D. W. Netzer, Professor of Aeronautics

Sponsor: Naval Weapons Center

Objective: To determine the effects of combustor geometry and flow conditions on the occurrence of combustion pressure oscillations.

Summary: An experimental investigation of the mechanisms involved in combustion pressure oscillations in solid fuel ramjets was conducted. Dynamic pressure measurements of the combustion chamber and air inlet were recorded, while a series of tests using Plexiglas as a fuel were performed. Combustion chamber geometric changes were systematically made in order to help isolate the portion(s) of the combustion/flow process which is capable of coupling with the air inlet system resonant frequency. Reattachment zone flow was found to be the major source of pressure oscillations while bypass air injection was the major source of disturbance to the upstream reattachment region of flow.

Conference Presentations: D. W. Netzer, "Modelling Solid Fuel Ramjet Combustion," presented at Chemical Systems Division, AFWAL Meeting on Ramjets, UTC, San Jose, CA, 28 October 1983.

T. Milshtein and D. W. Netzer, "Three-Dimensional, Primitive-Variable Model for Solid-Fuel Ramjet Combustion," 20th JANNAF Combustion Meeting, Monterey, CA, 17-20 October 1983, CPIA publication 383, Volume I, October 1983, pp. 653-660.

D. W. Netzer, "NPS Research on the Solid Fuel Ramjet," DARPA meeting on Advanced Ramjet and Munitions Technology, Monterey, CA, 17-18 April 1984.

Thesis Directed: T. M. Paraforito, "An Experimental Investigation of Combustion Pressure Oscillations in Solid Fuel Ramjets," Master's Thesis, March 1984.

Title: Effects of Smoke Suppressant Fuel Additives and Fuel Composition on Gas Turbine Combustor Emissions

Investigator: D. W. Netzer, Professor of Aeronautics

Sponsor: Naval Air Propulsion Center

Objective: Experimentally determine the effects of fuel additives and fuel composition on emitted particulate and NO<sub>x</sub> levels.

Summary: A gas turbine combustor test facility was designed and constructed, and an initial series of tests were conducted to determine combustor operating characteristics and the adequacy of the newly constructed combustor diagnostic apparatus. The facility utilizes a T-63 combustor. Water cooled gas/particulate sampling and stagnation temperature probes were utilized along the combustor centerline. Three-wavelength light transmission measurements through the combustor have been made to determine the mean soot size. Initial screening tests of six of ten reference fuels were completed. Major findings to date are:

- a) No significant effect of hydrogen or aromatics content on 'in combustor' particulate size or NO<sub>x</sub> concentration.
- b) Increasing NO<sub>x</sub> concentration increasing fuel-air ratio (or exhaust temperature).
- c) The T-63 combustor produces increased soot concentration with increased fuel-air ratio.
- d) Ferrocene and Cerium Hex-Cem were found to be ineffective in the T-63 combustor when using cold (480R) combustor inlet air temperatures. This is in contrast to the results obtained earlier using a dump-type burner which had long residence time at elevated temperatures. These two additives are apparently effective only in the soot oxidation processes (vs. soot formation processes).

Theses Directed: J. D. Weller, "A Parametric Investigation of Soot Behavior and Other Emissions in a Gas Turbine Combustor," Master's Thesis, June 1984.

A. L. Lohman, "An Investigation Into the Soot Production Process in a Gas Turbine Combustor," Master's Thesis, September 1984.

Title: Investigation of Unsteady Flow and Aeroelastic Problems in Aircraft Propulsion Systems

Investigator: M. F. Platzer, Professor of Aeronautics

Objective: To measure the effectiveness of a new jet excitation mechanism on the entrainment of subsonic jet and to serve as co-editor of the AGARD Manual on Aeroelasticity in axial turbomachines.

Summary: The entrainment effectiveness of a vane-excited subsonic jet were measured using conventional and optical measuring techniques. Also, the contributions of most U.S. authors to the AGARD Manual were received and the editing process has begun.

Publications: M. F. Platzer, D. J. Collins, T. R. McClellan, "Mixing Effectiveness of Vane-Excited Jets", Proceedings of Symposium on Fluid Dynamics, University of Illinois, 26-27 April 1984, pp. 81-92

D. J. Collins, W. H. Hardy, M. F. Platzer, "Measurements of Vane-Excited Jets", Proceedings of the 2nd International Symposium on Applications of Laser Anemometry to Fluid Mechanics, 2-4 July 1984, Lisbon, Portugal

Title: Development and Use of a Centrifugal Diffuser Test Device (CDTD)

Investigators: Dr. R. P. Shreeve, Director, Turbopropulsion Laboratory Department of Aeronautics and H. D. Schulz (Exotech Inc.), University of Aachen, W. Germany.

Sponsor: U.S. Army Research and Technology Laboratories (NASA Lewis Research Center)

Objective: To develop a satisfactory method for testing diffusers for centrifugal compressors and to use the resulting facility to verify NASA computer codes.

Summary: A novel device for generating and controlling an axi-symmetric flow into a typical centrifugal diffuser arrangement was built and installed in the low speed cascade building at TPL. Preliminary tests were conducted to investigate the ability to control swirl angle and case-wall boundary layers in the test device. A 32-vane diffuser geometry was selected for initial measurements. Five calibrated pneumatic-velocity probes and more than 200 static pressure taps were installed with provision for peripheral surveys. It was found that the mechanical system for controlling the flow angle worked, however the flow angles at first were somewhat less than expected. Modifications were made to obtain 58-72° and further changes are planned to improve peripheral uniformity and control of boundary layers before code verification data are attempted.

Publications: Erwin, J. R., Phillips, R., Schulz, H. D. and Shreeve, R. P., "Development of a Centrifugal Diffuser Test Device (CDTD). Part I-Design and Construction of Low Speed Apparatus", Naval Postgraduate School Project Report, NPS67-84-003PR, September 1984.  
Schulz, H. D. and Shreeve, R. P., "Development of a Centrifugal Diffuser Test Device (CDTD). Part II-Initial Measurements and Flow Analysis", Naval Postgraduate School Project Report, NPS67-84-004PR, September 1984.

Thesis Directed: Thrower-Lesesne, P. E. "Design of a Generator for Near-Tangential Transonic Swirling Outflow", M. S. Thesis December 1984.

Title: Compressor Tip Clearance Effects

Investigator: Dr. R. P. Shreeve, Director, Turbopropulsion Laboratory,  
Department of Aeronautics and I. Moyle (Exotech Inc.) U.  
of Tasmania, Australia.

Sponsor: Naval Air Systems Command

Objective: To investigate the effects of changes in tip clearance  
on the performance of and flow fields within a multistage  
axial compressor with a view to proposing an improvement  
in the usual design procedure which ignores the gap.

Summary: A 36-inch O.D. low speed three stage axial compressor  
having a 7.2-inch cylindrical flow path has been fitted  
with a single stage of "symmetrical" blading and first  
measurements of the performance map and internal flow  
profiles have obtained.

Work has concentrated on redesign of inlet guide vanes  
and subsequent fabrication to meet the required  
prerotation for the stage. An analytical method has also  
been developed to predict exit angles from accelerating  
blade rows. This technique is to be modified for rotors  
and the effect of tip clearance gap. Additional effort  
has been directed at design and fabrication of a low  
speed calibration facility for hot wires to be used for  
blade to blade flow field measurement. The  
instrumentation plan and data acquisition programs have  
been completed. Measurements will begin when new guide  
vanes are installed.

Publication: I. Moyle, "Inlet Guide Vane Design Techniques"  
(in progress).

Title: Transonic Compressor Investigations

Investigators: Dr. R. P. Shreeve, Director, Turbopropulsion Laboratory, Department of Aeronautics, and F. Neuhoff (Exotech Inc.), German Armed Forces University, Munich, W. Germany.

Sponsor: Naval Air Systems Command

Objective: To understand three-dimensional and unsteady effects and to obtain data with which to assess design and analysis methods for transonic blading.

Summary: A single stage transonic axial research compressor and test rig and several unusual measurement techniques have been developed toward the present study. In the past year, the DPDS (Dual-Probe Digital Sampling) Technique to measure blade-to-blade velocity vector distribution downstream of a rotor was refined to eliminate errors in wake regions. Measurements were made with rotor only and are being analyzed. Associated case-wall-mounted Kulite transducers showed strictly periodic pressure oscillation at 120-140 KHZ at blade passing frequencies from 6.1 to 6.4 KHZ, which may result from passage-shock oscillations coupled to vortex shedding. Loss measurements and velocity distributions derived from DPDS measurements will be compared with existing cascade models in future work.

Publications: R. P. Shreeve and F. Neuhoff, "Measurements of the Flow from a High Speed Compressor Rotor Using a Dual Probe Digital Sampling (DPDS) Technique," ASME Journal of Engineering For Gas Turbines and Power, Vol. 106, April 1984 pps 366-375.

Title: Numerical Simulation of Internal Flows

Investigators: Dr. R. P. Shreeve, Director, Turbopropulsion Laboratory, and S. Eidelman, Adjunct Research Professor, Department of Aeronautics

Sponsor: Naval Air System Command

Objective: To investigate the application of an unsteady Euler code based on the Godunov method of solution, to propulsion flow problems.

Summary: The two-dimensional "EGE" code developed earlier under NPS Foundation Research Program sponsorship was applied to specific test problems and then to problems of immediate research importance. First, it was found that inaccuracy in the calculation of flows with oblique shock waves could be greatly reduced by locally orienting the grid lines to be along and normal to the shock. Subsequently, the code was used to simulate numerically the flow in a wave rotor passage as the inlet port opens, and the passage of a detonation wave through a divergent passage.

Publications:

Eidelman S. "The Problem of Gradual Opening in Wave Rotor Passages", presented at the 19th Intersociety Energy Conversion Engineering Conference (IECEC), San Francisco, Aug 19-24, 1984. Published in AIAA Journal of Propulsion and Power, Vol. 1, No. 1 pps. 23-28.

Eidelman, S., Colella, P., and Shreeve, R. P., "Application of the Godunov and Its Second Order Extension to Cascade Flow Modeling", AIAA Journal, Vol. 22, No. 11, pp. 1609-1615, November 1984.

Eidelman S. and Shreeve, R. P., "Numerical Modeling of the Non-Steady Thrust Produced by Intermittent Pressure Rise in a Diverging Channel", ASME Winter Annual Meeting, New Orleans, ASME BK. No. G00273, December 1984.

Title: Development of a Transonic Compressor Model

Investigator: Dr. R. P. Shreeve, Director, Turbopropulsion Laboratory,  
Department of Aeronautics and F. Neuhoff (Exotech Inc.),  
German Armed Forces University, Munich, W. Germany.

Sponsor: Naval Air Systems Command

Objective: To develop a small transonic axial air compressor model  
and methods for measuring performance and flow behavior.

Summary: Associated with the project "Transonic Compressor Investigations" is the development of the test compressor and test rig hardware to design speeds of 30,460 RPM. Flow velocity distributions into and between blade rows of the prototype stage have been measured and compared with design distributions. Through-flow velocities less than design, giving incidence angles larger than design, were found at peak efficiency conditions. Modification of the inlet flow path, including spinner geometry, were made guided by flow field computations. The most significant improvement was obtained by increasing the level of the flow rate at open throttle. A radial distortion screen was required to generate the flow profile required by the blading. Correction of the flow near the hub was found to be impractical within reasonable means.

Title: Controlled Diffusion Blading Development

Investigator: Dr. R. P. Shreeve, Director, Turbopropulsion Laboratory,  
Department of Aeronautics

Sponsors: Naval Air Systems Command, NASA Lewis Research Center and  
Sundstrand Corporation

Objective: To obtain data using a large (60" x 10") subsonic cascade wind tunnel to verify computational codes used in the design of controlled diffusion (CD) blading and to measure the performance of specific designs.

Summary: Two CD blading designs have been examined. First, for NASA, a stator blade section designed using a numerical optimization procedure has been tested. The results are being compared with code predictions and with results previously obtained with a double-circular-arc (DCA) cascade which the CD blading was designed to replace. Second, for Sundstrand Corporation, a rotor fan blade section has been tested. For both designs, loss coefficients, deviation angles, AVDR and surface pressure distributions were obtained. The china clay technique was used to analyze surface flow conditions, including boundary layer transition, to allow interpretation of the blade-element loss data. Results for the NASA design were obtained over a full range of incidence angle. Results could not be obtained on the Sundstrand blading positive incidence angles since stalling of the tunnel (rather than the blading) occurred. Results are being analyzed and compared with code predictions.

Schulz, H. D., Neuhoff, F., Hirsch, Ch. and Shreeve, R. P., "Application of a Finite Element Code Q3DFL0-81 to Turbomachinery Flow Fields", Project Report, NPS67-84-005PR, September 1984.

McGuire, A. and Shreeve, R. P., "Subsonic Cascade Wind Tunnel Tests of a Sundstrand Controlled Diffusion Fan Blade Section", Project Report NPS67-84-021PR, December 1984.

Thesis Directed: Koyuncu, Y. "Report of Tests of a Compressor Configuration of CD Blading", Masters Thesis, March 1984.

Title: Wave Rotors and Wave Engines

Investigator: Dr. R. P. Shreeve, Director, Turbopropulsion Laboratory, Department of Aeronautics and Dr. A. Mathur, (Exotech Inc)

Sponsor: NPS Foundation Program and Naval Air Systems Command

Objective: To develop computational techniques to analyze the performance of and flows within wave rotor devices and to show through an experimental program that they work.

Summary: Extensive studies of past and current efforts related to research and development in wave rotor technology have been made to understand key features of the successes (and failures) of the various programs. A one-dimensional Euler code based on the Random Choice Method has been developed and adapted to model unsteady flows with discontinuities, typical of the flows in wave rotor passages. The design of a laboratory scale wave rotor experiment has been completed and the test rig has been assembled. Initial tests have indicated good mechanical integrity of the rig at high speeds (~15000 r.p.m.) and the device has demonstrated consistent self-acceleration at 5000-6000 r.p.m. when run in the 'wave turbine' mode. Further testing will continue after attaching an air dynamometer to absorb the generated shaft power.

Publications: Eidelman, S., Mathur, A., Shreeve, R. P. and Erwin, J., "Application of Riemann Problem Solvers to Wave Machine Design", AIAA Journal, Vol. 22, No. 7, pp. 1010-1012, July 1984.  
Mathur, A., Eidelman, S. and Shreeve, R. P., "Numerical Techniques for Wave Rotor Cycle Analysis", ASME Winter Annual Meeting Forum on Unsteady Flow, ASME Publication FED-VOL 15, December 1984.

**DEPARTMENT  
OF  
OCEANOGRAPHY**

## DEPARTMENT OF OCEANOGRAPHY

The research program of the Department of Oceanography may be considered under four headings, according to the facilities utilized and topics considered; coastal ocean studies; nearshore process studies; arctic studies; open ocean studies; and environmental acoustic studies.

### COASTAL OCEAN STUDIES

E. C. Haderlie uses R/V ACANIA to study the biology of stone and wood boring organisms in the deeper waters of Monterey Bay. His purpose is to determine and identify the vertical and horizontal distribution of these borers as well as their growth rates, settlement times, and destructive effects. The sponsor is the Office of Naval Research.

E. D. Traganza uses the R/V ACANIA in a study of the chemical mesoscale associated with ocean fronts in the coastal upwelling region off Pt. Sur. Cruises are coordinated with satellite imagery obtained from the National Environmental Satellite Service at Redwood City. This study attempts to link physical, chemical, and biological properties in this region. The sponsor is the Office of Naval Research.

### NEARSHORE PROCESS STUDIES

E. B. Thornton is studying the kinematics and energetics of breaking waves in the surf zone. His research is based on measurements of water particle motion within the surf zone. The sponsor is the Office of Naval Research.

### ARCTIC STUDIES

R. G. Paquette and R. H. Bourke use U.S. Coast Guard icebreakers to observe and analyze ocean fronts and thermal fine-structure near the ice margin in the East Greenland Current. These studies have applications for environmental acoustics and under-ice submarine operations. The sponsors are the Arctic Submarine Laboratory, NOSC, and NSWC.

### OPEN OCEAN STUDIES

R. W. Garwood, in conjunction with R. L. Elsberry and R. L. Haney of the Department of Meteorology, is modeling upper ocean thermal structure. Their investigations of the response of the ocean surface turbulent boundary layer to atmospheric forcing have led to the development of models that can be used to compute upper ocean thermal structure changes if the atmospheric conditions are known. The sponsor is the Office of Naval Research. This effort has led to an applied research program in which the models are used to aid in the analysis of the upper ocean thermal structure, especially in those regions of the ocean that lack frequent observations. NORDA is the sponsor.

E. B. Thornton and T. P. Stanton are studying the properties of velocity shears and density gradients in the upper ocean. The sponsor is the Office of Naval Research.

J. L. Mueller is investigating the effects of horizontal variability in ocean properties on the validity of optical propagation predictions based on one-dimensional models of the upper ocean. The R/V ACANIA is used, especially in the large field experiment called ODEX. This is part of a Selected Research Opportunity (SRO) program sponsored by ONR in support of the proposed Strategic Laser Communications (SLC) system.

T. R. Osborn and R. G. Lueck are designing, building, testing and using horizontal and vertical sampling systems for ocean turbulence. They make measurements from ships (including the R/V ACANIA) and submarines, and in the North Atlantic, North Pacific, and Equatorial Pacific. The sponsors are the Office of Naval Research, NORDA, and National Science Foundation.

C. N. K. Mooers, M. M. Rienerker, and J. A. Smith are conducting an ocean prediction study in collaboration with Harvard using the Harvard statistical-dynamical model for open domains. Their study is presently focused on eddies, fronts, and jets in the California Current System. Ten synoptic realizations of the upper ocean have been acquired with oceanographic sampling from the R/V ACANIA and other vessels and planes. The sponsor is the Office of Naval Research.

#### ENVIRONMENTAL ACOUSTICS

G. H. Jung, R. H. Bourke, C. R. Dunlap, S. W. Yoon, A. B. Coppens, and T. F. Clark study relations between atmospheric and oceanic variations and long-range, low-frequency sound propagation and ambient noise in the North Pacific Ocean. Satellite IR imagery is used to infer and interpret oceanic and acoustic variability. The sponsors are NOSC (for COSP NAVELEX) and NORDA.

C. R. Dunlap, R. H. Bourke, and G. H. June are studying the performance of vertical line array sensors. The sponsor is ASW Systems Project Office.

C. R. Dunlap, E. C. Haderlie, J. P. Powers, and B. Wilson are investigating the effects of the ocean on fiber optic cables to be used in fixed distributed acoustic systems. The sponsor is DARPA.

Title: Chair in Arctic Marine Science

Investigators: R. H. Bourke, Associate Professor of Oceanography,  
W. O. Smith, Adjunct Research Professor of Oceanography

Sponsor: Office of Naval Research

Objectives: To foster oceanographic research in the Arctic,  
acquaint naval officer students with Arctic  
problems, reduce results of pure research to  
operational usage, and publicize Navy interest in  
the Arctic.

Summary: Professor Bourke has served as administrator of the  
Chair handling such details and selecting Chair  
candidates, writing IPAs and proposals, and setting  
up visits and seminars for the Chair incumbent.  
Professor Smith, a biological oceanographer from the  
University of Tennessee, was the Chair incumbent  
during FY 84. He had an active year in the field  
carrying out projects in Antarctica and in the Arctic,  
the latter as part of the MIZEX experiment. Smith  
served as the biology disciplinary chairman of MIZEX.  
His work is chiefly involved with the response of  
plankton population dynamics to forces active at  
the ice-margins of the Polar seas.

Title: Studies in Support of NSWC, 1985

Investigators: R. H. Bourke, Associate Professor of Oceanography,  
and C. R. Dunlap, Adjunct Research Professor of  
Oceanography

Sponsor: Naval Surface Weapons Center

Objectives: To assist in thesis research on topics of interest  
to NPS and PSWC.

Summary: NSWC has established an experience tour program for  
NPS Air-Ocean Sciences students to spend up to  
six weeks at NSWC and other locations conducting  
research of mutual benefit to NPS and NSWC. During  
1984 the topic selected for investigation is to  
determine the thickness of Arctic sea-ice at any  
time or place. Data are from past submarine under-  
ice cruise and literature reviews. In addition,  
other factors such as pressure ridging and lead  
statistics and measures of variability will be  
addressed. LCDR Robert Garrett, USN, traveled  
to NSWC, CRREL, University of New Hampshire, Arctic  
Submarine Laboratory and the Polar Research  
Laboratory to gather data. Prof. Bourke attended  
the Ice Penetration Workshop at CRREL, June 12-13  
1984, as part of this effort.

Title: Continued developed of a towed body system and expendable dissipation profilers

Investigators: D. E. Colton, Adjunct Research Professor of Oceanography, T. R. Osborn, Professor of Oceanography, and R. G. Lueck, Adjunct Research Professor of Oceanography

Sponsor: Naval Ocean Research and Development Activity

Objective: Development and fabrication of a larger and more sophisticated towed body system that would allow for data acquisition in C-SALT experiments in the Caribbean. We are continuing to develop and test expendable dissipation profilers (XDPs) with a goal of simplifying construction and increasing durability and depth limitation of the instrument for Gibralter Straits experiment.

Summary: Our present towed body is being modified with a new pressure case, external housings and towing hardware. We are in a preliminary stage of design and fabrication of the above mentioned items. The XDP has been simplified in construction as well as increased in durability. We have supplied NORDA with thirty-six of these units and have achieved increases in success and reliability.

Title: Ocean Microstructure experiments in conjunction with the submarine USS DOLPHIN

Investigators: D. E. Colton, Adjunct Research Professor of Oceanography, T. R. Osborn, Professor of Oceanography, and R. G. Lueck, Adjunct Research Professor of Oceanography

Sponsor: Office of Naval Research

Objective: Our goal is to collect ocean microstructure and biological data using a submarine as a stable underwater vehicle. Our objective is to look at vertical stratification of plankton collected from areas of shear and temperature differences, photograph plankton and plumes of air bubbles forced down from the sea surface to substantiate data collected from acoustic instruments.

Summary: A survey of turbulence measurements and biological data collected by the submarine are being analyzed. Areas of interest are stratification of plankton, salt finger signatures, forming of air bubble plumes and the effect of biologicals on turbulence sensor data.

Title: Environmental Acoustic Studies of Vertical Line Array (VLA) Sensors

Investigators: C. R. Dunlap, Adjunct Professor of Oceanography, R. H. Bourke, Associate Professor of Oceanography, and G. H. Jung, Emeritus Professor of Oceanography

Sponsor: Anti-Submarine Warfare Systems Project Office

Objective: To gain a better technical understanding of VLA performance, operational utilization and a measure of confidence in associated environmental acoustic support aids. To develop and analyze a VAL data base. To compare results from standard performance predictions and related environmental acoustic measurement techniques to observed results and to establish quantitative measures of confidence.

Summary: Operationally-oriented studies were carried out using PHITAR-V predictions for vertical line array-DIFAR (VLAD) sonobuoys. The ANODE meter amendment to VLAD was investigated and the ISANC program utilized. Results were reviewed by the Manager of the ASW Systems Program who wrote a letter of commendation to the NPS Superintendent saying, in part, "The final product provides evidence of a very competent investigation and well-thought-out conclusions and recommendations... Several specific recommendations...are being taken for action by my staff."

Title: Oceansystem Performance Assessment and Acoustic Array Characteristics

Investigators: C. R. Dunlap, Adjunct Professor of Oceanography,  
G. H. Jung, Emeritus Professor of Oceanography,  
R. H. Bourke, Associate Professor of Oceanography,  
and T. F. Clark, AT&T Technologies, Inc.

Sponsor: Naval Electronics Systems Command

Objective: To analyze the effect of environmental and acoustic phenomena on Integrated Undersea Surveillance Systems (IUSS) detection capability. To utilize selected cases where operational and research data are available for this analysis. To assess temporal and spatial noise patterns and their effect on operational performance.

Summary: A set of operational data collected in the Bering Sea in June 1982 was analyzed in an effort to explain variations in detection capability. Particular attention was given to a widespread shallow sound channel, its characteristics and its variability. These results were then verified and extended by analysis of another data set from July 1983. Studies of low frequency ambient noise were also conducted using information from the Norwegian Sea.

Title: Fixed Distribution Systems: Environmental Acoustics and Fiber Optic Communications

Investigators: C. R. Dunlap, Adjunct Professor of Oceanography, E. C. Haderlie, Distinguished Professor of Oceanography, J. P. Powers, Professor of Electrical and Computer Engineering, B. Wilson, Professor of Physics

Sponsors: Defense Advanced Research Projects Agency and Commander Naval Electronics Systems Command

Objective: To investigate the environmental effects on fixed distributed acoustic systems by study of a sample system to be installed in Monterey Bay. Additional study is on the use of fiber optic cables for transmitting the data.

Summary: In this new project, a long-wavelength single-mode fiber optic system has been designed for installation at high data rates. Supplies and instrumentation have been identified and ordered for the laboratory construction and testing of the fiber optic link. A candidate fiber cable has been successfully tested in a towing configuration for mechanical robustness. The result of the latter test was the subject of a congratulatory TELEX message from the DARPA Project Officer on 21 August 1984. Several cable systems were investigated with regard to survivability to fishbite.

Thesis Directed: R. W. Clary, Jr., "Fishbite Damage to Towed Arrays, Fixed Bottom Cable Systems and Floating Wire Antennas," Master's Thesis, September 1984.

Title: Ocean Shallow Sound Channel Effects in the FACT 9H Acoustic Transmission Loss Model

Investigators: C. R. Dunlap, Adjunct Professor of Oceanography,  
S. W. Yoon, Adjunct Professor of Physics

Sponsor: Naval Ocean Research and Development Activity

Objective: To investigate the acoustic and oceanographic characteristics of shallow sound channels in deep water of the North Pacific and to see how the Fast Asymptotic Coherent Transmission (FACT) 9H model treats the shallow sound channels.

Summary: Propagation in a shallow sound channel of deep water was investigated directly by running the FACT 9H model. Based on a canonical sound velocity profile in deep water of the North Pacific, modified fourteen cases were studied for five frequencies: 20, 50, 100, 150 and 200 Hz. This investigation showed an existence of an optimum frequency (not always the cutoff frequency) of the propagation in the shallow sound channel when the source and the receiver were located within the shallow sound channel.

Publication: C. R. Dunlap, D. G. Browning, and J. W. Powell,  
"Shallow Sound Channels in the North Pacific:  
Causes, Characteristics, and Durations", Abst.,  
108th Meeting, ASA, Minneapolis, MN, October 8-12,  
1984. Journal of the Acoustical Society of America,  
Supp. 1, V. 76, p. S84, 1984.

Title: Upper Ocean Acoustic Effects

Investigators: C. R. Dunlap, Adjunct Professor of Oceanography,  
G. H. Jung, Emeritus Professor of Oceanography, and  
R. H. Bourke, Associate Professor of Oceanography

Sponsor: Naval Electronics Systems Command

Objective: To improve the technical understanding of relations between sea surface roughness data and generation of surveillance-related ambient noise. To design a drifting buoy system to permit synoptic measurement of the ambient noise field concurrently with environmental surface roughness data.

Summary: An analysis has been made of the ASTREX data base previously collected in the Northeast Pacific; hindcasts of ambient noise were made depending on the DANES model and reconstructed environmental fields from FNOC. Wind-generated noise from distant storms was not a significant factor in the DANES hindcasts. Local wind effects appear to dominate the noise spectrum above 400 Hz. Shipping noise contributions from the Historical Temporal Shipping (HITS) data base appeared to dominate the hindcasts below 300 Hz. Design modification of the standard drifting buoy manufactured by Polar Research Laboratory, Carpinteria, CA is now underway, so that hydrophones can be accommodated and decoupled from the buoy motion due to sea state.

Title: Environmental Acoustic Studies of Acoustic Signal Transmission in the Wavenumber Domain

Investigators: C. R. Dunlap, Adjunct Professor of Oceanography and  
A. B. Coppens, Professor of Physics

Sponsor: Naval Ocean Research and Development Activity

Objective: To gain a better technical understanding of the Wavenumber Technique (WT), which is a relatively new method of underwater sound transmission analysis

Summary: Using the split-step Fourier transform (SSFT) and implicit finite difference (IFD) methods for the Parabolic Equation transmission loss model, the wavenumber technique was analyzed under various environmental conditions. The SSFT was unable to place transmission nulls at the correct ranges for the sample Lloyd mirror case. IFD produced the proper nulls, however it inserted an unacceptable amount of noise except when small (1m) vertical grid steps were used and the pressure release bottom was placed at extended depths. Neither model was able to provide accurate source depth information but further research is required to see if this technique can be used operationally for target depth determination.

Publication: J. L. Blanchard, and C. R. Dunlap, "Environmental Acoustic Studies of Acoustic Signal Transmission in the Wavenumber Domain", DARPA Workshop on Fixed Distribution Systems, Applied Research Laboratory, University of Texas, Austin, TX, September 1983.

Thesis Directed: J. L. Blanchard, "A Comparison of Two Acoustic Parabolic Equation Transmission Loss Models for Compatibility with the Wavenumber Technique in the Determination of Source Depth, Master's Thesis, March 1984.

Title: Studies of the Oceanic Planetary Boundary Layer

Investigator: R. W. Garwood, Jr., Associate Professor of Oceanography

Sponsor: Office of Naval Research

Objective: The long range scientific objective of this research is to understand the role of the oceanic planetary boundary layer (OPBL) in the distribution of energy, momentum and mass in the upper ocean in response to atmospheric forcing.

Summary: Mathematical models of entrainment and ocean mixing are developed and verified by comparison of numerical simulations with oceanic observations for such processes as the unsteady response of the mixed layer to changing atmospheric forcing and the response of upper ocean density fronts to local atmospheric forcing. Other processes involving application of turbulence closure modeling include: i) an investigation of the role of planetary rotation upon entrainment in deep mixed layers; ii) the use of nutrient data as a chemical tracer of mixed layer dynamics; iii) the nature and importance of coupling and feedback between the OPBL and the marine atmospheric boundary layer (MABL); iv) the interaction between interior motion and boundary layer processes; and v) mixing dynamics in the tropical Pacific Ocean.

Publications:

D. Adamec and R. W. Garwood, Jr., "The simulated response of an upper ocean density front to local atmospheric forcing". J. Geophys. Res., forthcoming.

K. L. Davidson and R. W. Garwood, Jr., "Coupled oceanic and atmospheric mixed layer model". Dyn. Atoms. Oceans, forthcoming.

P. Muller, R. W. Garwood, Jr. and J. P. Garner, "Effect of vertical advection on the dynamics of the oceanic surface mixed layer". Annales Geophys., forthcoming.

P. C. Gallacher, A. A. Bird, R. W. Garwood Jr. and R. L. Elsherry, "A determination of the constants for a second-order closure turbulence model from geophysical data". Naval Postgraduate School Technical Report NPS 63-83-004, 35 pp., 1983.

P. C. Gallacher, R. L. Elsberry, R. W. Garwood, Jr. and A. A. Bird, "A mixed layer model simulation of the three-dimensional upper ocean temperature field in the central North Pacific". Research Activities in Atmospheric and Oceanic Modelling, Ed. I. D. Switzerland, 8.12-8.14, 1983.

R. W. Garwood, Jr., P. C. Gallacher and P. Muller, "Wind direction and equilibrium mixed layer depth: Theory for a bulk model". Submitted to J. Phys. Oceanogr., 1984.

R. W. Garwood, Jr., P. Muller and P. C. Gallacher, "Wind direction and equilibrium mixed layer depth: Application to the tropical Pacific". Submitted to J. Phys. Oceanogr., 1984.

Conference Presentation:  
P. C. Gallacher and R. W. Garwood, Jr., "The interaction of planetary rotation and turbulent vorticity in the upper ocean mixed layer at mid-latitudes". Fifth Conference on Ocean-Atmosphere Interaction, Miami, 1984.

Theses Directed:  
D. C. Copley, "The Effect of Stochastic Surface Heat Fluxes on the Climatology of the Seasonal Thermocline", Master's Thesis, June 1984.

J. P. Garner, "The Effect of Interior Motion on Seasonal Thermocline Evolution", Master's Thesis, December 1983.

R. V. Hervey, "Sensitivity Analysis of a Coupled Atmospheric-Oceanic Boundary Layer Model", Master's Thesis, June 1984.

K. Pollack, "Real-Time Enhancement of a Climatology or Forecast of Ocean Thermal Structure Using Observed Ocean Temperatures", Master's Thesis, June 1984.

Title: Biology of Stone and Wood Boring Animals in the Monterey Submarine Canyon and the Deeper Waters off the Central California Coast

Investigator: E. C. Haderlie, Distinguished Professor of Oceanography

Sponsor: Office of Naval Research

Objectives: To determine the vertical and horizontal distribution of stone and wood boring marine animals of the deeper waters of Monterey Bay and to determine the rates of growth and the destructive activities of the organism in wood, stone, concrete and plastic. To attempt to learn the specific mechanisms used in boring into hard substrate.

Summary: During the past year a cooperative effort with scientists from the Woods Hole Oceanographic Institute has made it possible for us to continue physiological studies of living animals. We now know that one group of boring molluscs do indeed bore mechanically as has been suspected, but we have yet to solve the problem of how date mussels and their relatives penetrate very hard stone.

Publications:

E. C. Haderlie, A Brief Overview of the Effects of Fouling. In: Marine Biodeterioration, and Interdisciplinary Study. J. C. Costlow and R. C. Tipper, Eds. pp. 163 - 166. Naval Institute Press, Annapolis, 1984.

E. C. Haderlie, Possible Mechanisms used by Marine Bivalves in Penetration Hard Siliceous Stone. Proceedings of the 6th International Congress on Marine Corrosion and Fouling, Athens, September 1984, forthcoming.

E. C. Haderlie, A Report on the 6th International Congress on Marine Corrosion and Fouling held in Athens, September 1984, forthcoming in European Scientific Notes - ONR London.

Title: Eddies in the California Current System

Investigator: C. N. K. Mooers, Professor of Oceanography

Sponsor: Office of Naval Research

Objective: To determine the scientific requirements for practical forecasting of mesoscale ocean variability (eddies, fronts, and jets), and to increase our quantitative understanding of the kinematics, dynamics, and energetics of the eddies, fronts, and jets in the California Current System.

Summary: A series of real-time ocean forecasting experiments are being carried out off Northern California as part of the OPTOMA Program. The OPTOMA (Ocean Prediction Through Observation, Modeling, and Analysis) Program is a joint NPS/Harvard Project. The elements of the ocean descriptive/predictive system employed include an observing system and statistical and dynamical models. The observing system includes in situ measurements of the oceanic mass field in the upper ocean made from R/V ACANIA, R/V DE STEIGUER, R/V MCARTHUR, and P-3s, and satellite remote sensing of sea surface temperature patterns using IR imagery. The instantaneous California Current System has been determined to consist of turbulent jets meandering between counter-rotating synoptic/mesoscale eddies of ca. 100 km diameter. Frequently the jets entrain coastal waters, producing cool anomalies at and near the sea surface, with strong fronts along their boundaries. In addition to a series of exploratory and statistical/kinematical field studies, prototype prediction experiments were conducted in the summers of 1983 and 1984. Two highly successful consecutive two-week forecasts were achieved during the month-long experiments in 1983. In 1984, forecasts were made and verified over a two-month period, again with appreciable success though the regime was in a different state. Further prediction experiments are planned over the next several years.

Publications: C. N. K. Mooers, A. R. Robinson, Turbulent Jets and Eddies in the California Current and Inferred Cross-Shore Transports (1984) Science, 223:51-53.  
A. R. Robinson, J. A. Carton, C. N. K. Mooers, L. J. Walstad, E. F. Carter, M. M. Rienecker, J. A. Smith, and W. G. Leslie, A Real-Time Dynamical Forecast of Ocean Synoptic/Mesoscale Eddies, Nature, 309: 781-783, 1984.

Publications  
Continued:

M. M. Rienecker, C. N. K. Mooers, D. E. Hagan, and  
A. R. Robinson, A Cool Anomaly Off Northern California:  
An Investigation Using IR Imagery and In Situ Data,  
Journal of Geophysical Research (forthcoming).

J. A. Smith, C. N. K. Mooers, and A. R. Robinson,  
Estimation of Quasi-Geostrophic Model Amplitudes  
from XBT/CTD Survey Data, Journal of Atmospheric  
and Oceanic Technology, forthcoming.

Title: CNOC Research Chair in Oceanography

Investigator: C. N. K. Mooers, Professor of Oceanography

Sponsor: Commander, Naval Oceanography Command

Objective: To promote the development of numerical ocean prediction, and to increase the interactions of the Oceanography Department with the Fleet Numerical Oceanography Center.

Summary: Professor Dale B. Haidvogel, National Center for Atmospheric Research, served in the Chair. He developed a new numerical model for coastal ocean circulation, which can be applied to the California coastal regime. He developed and taught an advanced graduate course in numerical ocean circulation modeling. Prof. Haidvogel provided much advice to students and faculty in their research, and he presented several seminars, including one at FNOC. Prof. Myron B. Fiering, Harvard University, also served in the Chair for two months; he worked on a new statistical prediction model for use in ocean analysis and forecasting.

Title: CNO Research Chair in MC&G and Hydrography

Investigators: C. N. K. Mooers, Professor of Oceanography and  
J. J. von Schwind, Associate Professor of Oceanography  
and Geodetic Sciences

Sponsor: Commander, Naval Oceanography Command

Objective: To promote the development of a progressive student/  
faculty research program in MC&G and Hydrographic  
Science NPS.

Summary: Prof. Rolland L. Hardy, Iowa State University,  
occupied the Chair for the year. He did research on  
multiquadric interpolations schemes (etc).

Thesis Directed: A. Saman, "A Comparison of Methods of Least Squares  
Adjustment of Traverses". Master's Thesis.  
September 1984.

P. J. Rakowsky, "Real-Time Point Posisiton and  
Baseline Determinations Using the GPS T14100  
Receiver". Master's Thesis. September 1984.

Title: Horizontal Variability Effects on Optical Propagation  
in the Upper Ocean

Investigator: J. L. Mueller, Adjunct Professor of Oceanography

Sponsor: Office of Naval Research

Objective: To account for and test the effects of horizontal variability and advection in a model forecasting optical propagation in the upper ocean

Summary: As part of the Office of Naval Research sponsored SRO project entitled "Environmental Effects on Optical Propagation", the present project contributes a study of the effects of horizontal variability on predictions fo downward vector irradiance propagation. A major goal of the parent program is the development and testing of an irradiance propagation forecast model for the upper ocean in support of the Navy's performance evaluation of the proposed Strategic Laser Communications (SLC) system. A major expedition (forty-two days duration) was staged aboard R/V ACANIA during the Optical Dynamics Experiment (ODEX) in October - November 1982. Two follow-up cruises staged in October 1983 and April 1984. Processing and analysis of data acquired during these cruises, together with an associated sequence of bio-optical maps derived from CZCS images, proceeded throughout the remainder of the reporting period. The first manuscripts reporting results of these studies are now in preparation; completion of these manuscripts is being supported by the ONR sponsor under a continuation of the related project: "Optical variability in NE Pacific water masses".

Conference Publications: J. L. Mueller, "Optical variability in the eastern North Pacific Ocean as measured by the Nimbus-7 Coastal Zone Color Scanner." Presented at the Pacific Congress on Marine Technology, Honolulu, April 24 - 27 1984. (Extended Abstract).

Title: Optical Variability in NE Pacific Water Mass

Investigator: J. L. Mueller, Adjunct Professor of Oceanography

Sponsor: Office of Naval Research

Objective: To characterize jointly the horizontal structure and scales of optical, biological, chemical and physical properties of near surface water masses in the NE Pacific Ocean between 30 and 27 N latitude.

Summary: This study combines descriptive, dynamical and statistical analyses of Nimbus-7 Coastal Zone Color Scanner (CZCS) bio-optical images, and in situ observations of optical, biological, chemical and physical water mass properties. In situ data were obtained in prior years and in the present reporting period on two R/V ACANIA cruises in October 1983 and April 1984. An ensemble of CZCS images is being analyzed using partitioned empirical orthogonal function methods, and through comparison with associated variability in optical, biological and physical oceanographic profiles along cross shelf sections.

Publications: J. L. Mueller, "Effects of water reflectance at 670 nm on Coastal Zone Color Scanner (CZCS) aerosol radiance estimates off the coast of central California". In: Ocean Optics VII, M. Blizzard, ed., SPIE Vol. 489, pp. 179 - 186.

Thesis Directed: J. T. McMurtrie, "Spatial Structures in Optical Parameters in the California Current as Measured with the Nimbus-7 Coastal Zone Color Scanner". Master's Thesis. March 1984.

Title: Marginal Sea-Ice Zone Studies 1984

Investigators: R. G. Paquette, Professor of Oceanography and  
R. H. Bourke, Associate Professor of Oceanography

Sponsor: Arctic Submarine Laboratory

Objective: Carry out physical oceanographic research,  
including field measurements, in the marginal sea-  
ice zone of the Bering, Chuckchi and Greenland Seas.  
This work has the long-term applied objective of  
facilitating the operation of submarines under ice.  
It is part of the continuing MIZPAC and MIZLANT  
programs.

Summary: This is an ongoing program to study the frontal  
and finestructure phenomena associated with the  
ice edges of the Atlantic and Pacific Oceans.  
Measurements, primarily CTD lowerings, have been  
carried out from ice breakers since 1971 and include  
observations both in summer and winter. During 1984  
we completed the data editing of the October 1981  
cruise to the East Greenland Polar Front (EGPF) and  
completed a paper which discussed the oceanography of  
this region based on the 1981 cruise. We prepared for  
and carried out a cruise to the EGPF and continental  
shelf areas between 75 degrees and 82 degrees North  
during August - September 1984. This cruise had  
the dual objectives of mapping the sea floor  
bathymetry and characterizing the physical oceanographic  
features of the waters overlying the shelf and at  
the front. A student, LCDR Sleichter, is completing  
a study of acoustic propagation conditions across  
the EGPF.

Publication: R. G. Paquette, R. H. Bourke, J. L. Newton, and  
W. F. Perdue, "The East Greenland Polar Front in  
Autumn", forthcoming in Journal of Geophysical Research.

R. H. Bourke, "Frontal Conditions, Finestructure,  
and Double Diffusion in the East Greenland Polar  
Front", Seminar presented at Naval Ocean Research  
and Development Activity, July 2, 1984.

R. H. Bourke, R. G. Paquette, and J. L. Newton,  
"Finestructure and Double-Diffusion in the East  
Greenland Polar Front", Ocean Sciences Meeting  
of the American Geophysical Union, New Orleans,  
January 23 - 27 1983. Abstract in: EOS, Trans.,  
American Geophysical Union, 64(52): 1059, 1983.

Thesis Directed: W. T. Sleichter, "Modeling Acoustic Propagation  
Across the East Greenland Polar Front", Master's  
Thesis, forthcoming.

Title: Density, Shear and Turbulence Measurements in the Upper Ocean

Investigators: E. B. Thornton, Professor of Oceanography and  
T. P. Stanton, Adjunct Research Professor in  
Oceanography

Sponsor: Office of Naval Research

Objective: It is proposed to make upper ocean profile measurements of density, velocity and acoustic backscatter in the vicinity of FLIP during MILDEX in October 1983. These measurements will be used to define vertical and horizontal scales of the upper ocean structure advecting relative to FLIP. Secondly, measurements of shear using a free-falling acoustic doppler profiler and airfoil probes will be used to determine shear scales throughout the water column. Thirdly, the feasibility of measuring turbulence induced by the straining of the wave field in the nearsurface by the mean shear flow is to be determined; measurement of surface elevation, velocity shear and shear microstructure near the surface will be made from the RS DOLPHIN.

Summary: Analysis is proceeding on data collected during a ten day, 5 km box-section time series of current and C/T profiles measured at the MILDEX site in October 1983. The observed changes in the mixed layer are to be modeled in terms of both the measured atmospheric forcing and the internal wave field, and the directly measured stability of the water column spanning the mixed layer. Collaborative experiments with Tom Osborn and Rolf Lueck using the R/V DOLPHIN were conducted in April and October 1984 measuring high resolution shear, C/T and dissipation profiles. Current profile measurements from a 1.2 MHZ doppler profiler are used to measure 1 m-30 m vertical shear scales in close proximity to velocity and temperature microstructure probes in order to determine the horizontal and vertical extent of high dissipation regions in the upper ocean.

Title: Test and Evaluation of Sea, Swell and Surf Programs (SSSP)

Investigators: E. B. Thornton, Professor of Oceanography

Sponsor: Naval Environmental Research Facility

Objective: It is proposed to convert the FORTRAN Code for the Sea, Swell and Surf Program (SSSP) to a BASIC Code to run on a Hewlet-Packard 9845B-275 mini-computer. Test and evaluation will be performed on the model using extensive available wave and surf data from La Jolla, CA, Santa Barbara, CA, and Duck, North Carolina. These field experiments cover a wide variety of wave and surf conditions.

Summary: New proposal.

Title: Nearshore Wave Properties

Investigator: E. B. Thornton, Professor of Oceanography

Sponsor: Office of Naval Research

Objective: Basic studies are being made on the kinematics of breaking waves within the surf zone in the field. The specific objectives of the proposed research are: (1) determine breaking criterion as a function of depth, beach slope and wave frequency and (2) determine the transformation of waves across the surf zone due to energy conversion and dissipation in the breaking process.

Summary: Research this past year emphasized the continued analysis of the results of the major field experiments at Torrey Pines, California and Santa Barbara, California, and the development of predictive models. A model describing the transformation of random wave heights was developed based on energy flux balance. Dissipation is considered due to wave breaking and bed friction. Wave breaking is characterized after periodic bores. The random nature of the wave heights is described starting with the Rayleigh distribution in deep water. The Rayleigh distribution is modified by wave breaking with an empirical transfer function. The modified distribution is itself the Rayleigh distribution. The model is compared both with laboratory results and an extensive set of field measurements collected at Torrey Pines Beach, California. The model is able to predict the increase in averaged wave height due to shoaling and subsequent decrease due to wave breaking. The model has only one adjustable parameter and is able to predict rms wave heights to within a standard error of 9.3% throughout the region from offshore to the beach.

Publications: R. T. Guza, and E. B. Thornton, "Wave Set-up on a Natural Beach," J. of Geophysical Research, 86, 4133-4137, 1981.

D. A. Huntley, R. T. Guza and E. B. Thornton, "Field Observations of Surf Beat: Part 1, Progressive Edge Waves," J. of Geophysical Research, 86, 6451-6466, 1981.

R. T. Guza, and E. B. Thornton, "Swash Oscillations on a Natural Beach," J. of Geophysical Research, 87, 483-491, 1982.

E. B. Thornton, and R. T. Guza, "Longshore Currents and Bed Shear Stress," Proceedings of the Directional Wave Spectra Applications, '81 Conference, ASCE, 147-164, 1981.

E. B. Thornton, and R. T. Guza, "Energy Saturation and Phase Speeds Measured on a Natural Beach," J. of Geophysical Research, 87, 9499-9508, 1982.

E. B. Thornton, and R.T. Guza, "Transformation of Wave Height Distribution," J. of Geophysical Research, 88, 5925-5938, 1983.

R. T. Guza, and E. B. Thornton, "Velocity Moments in the Nearshore," accepted in the J. Waterways, Harbours and Coastal Engineering.

E. B. Thornton, and R.T. Guza, "Longshore Currents Generated by Random Waves," submitted to J. of Geophysical Research.

R. T. Guza, and E. B. Thornton, "Surf Beat Climatology" accepted in the J. of Geophysical Research.

E. B. Thornton, and R. T. Guza, "Chapter 4: Measuring the Surf Zone," Nearshore Sediment Transport Study Monogram, Elsevier Press (forthcoming).

E. B. Thornton, and R. T. Guza, "Chapter 8: Wind Wave Transformation," Nearshore Sediment Transport Study Monogram, Elsevier Press (forthcoming).

- Publications:
- R. T. Guza, and E. B. Thornton, "Chapter 9: Runup and Surf Beat," Nearshore Sediment Transport Study Monogram, Elsevier Press (forthcoming).
- E. B. Thornton, and R. T. Guza, "Chapter 10: Nearshore Circulation," Nearshore Sediment Transport Study Monogram, Elsevier Press (forthcoming).
- E. B. Thornton, and R. T. Guza, "Chapter 16: Models for Surf Zone Dynamics," Nearshore Sediment Transport Monogram, Elsevier Press (forthcoming).
- C. -S. Wu, E. B. Thornton and R. T. Guza, "Nearshore Current Model Compared with Field Data," accepted in the J. of Geophysical Research.

**DEPARTMENT  
OF  
MECHANICAL ENGINEERING**

## DEPARTMENT OF MECHANICAL ENGINEERING

The research program in the Department of Mechanical Engineering has continued in several areas: applied mechanics; heat transfer; hydrodynamics and fluid mechanics; and materials science.

### APPLIED MECHANICS

Professor Cantin has continued his activities in Computer Aided Engineering (C.A.E.). The M.E. Lab for C.A.E. has been equipped with an APOLLO DM300 work station especially well adapted for C.A.E. applications. A graphic package was obtained from the DANFORD Corporation and installed in the machine. Then the GIFTS system was modified and is now running in the APOLLO computer. Modifications were required in some 75 subroutines.

Professor Culbreth has been conducting research on developing shape memory alloy actuators for use in robotics that employ liquid and gas forced convection cooling in lightweight enclosures. A plexiglas enclosure was constructed to determine the transient response of shape memory alloy coils under various types of cooling and power input. Thermocouples were attached at three different points along the coils and at the inlet and outlet nozzles of the enclosure. The displacement of the actuator as a function of time was measured and the time constant of the coils was determined for various flow rates and cooling conditions. Results indicated that such enclosures can serve as insulators to decrease heat loss during actuation and as excellent coolers when return to the remembered shape is desired.

Professor Newton has continued his research on use of the finite element method to analyze the response of submerged structures to underwater shock waves. During the past three years he has collaborated with Professor R. T. Williams of the Meteorology Department on application of the finite element method to numerical weather prediction. This research is continuing.

Professor Nunn has been conducting research on development of simulation and design codes for electromechanical actuators. Work is in support of the NWC program, "Advanced Missile Control Devices." A study was begun to model and simulate a missile fin actuation system driven by a brushless dc motor. The preliminary studies were performed on the modeling of the motor, drive-train, and load using the usual linear descriptions. Simulation of

system response to step and frequency inputs was accomplished using the Continuous System Modeling Program. Initial qualitative results show that the model successfully predicts the effects expected from variations in load and damping. Further evaluation of the model and possible refinements will require the availability of test data.

Professor Shin has continued his research for DTNSRDC on developing acoustic damping measurement and modal testing of naval material at low stress level, high frequency range, and various temperatures in a water environment. The measurement techniques include the impact hammer technique and the random excitation method. Sensitivity studies were performed to evaluate how various parameters affect the damping such as boundary conditions, size of specimen, sensor mounting method, etc. Professor Shin has also continued his research for the Defense Nuclear Agency on numerical and experimental studies of the underwater shock-induced responses of the submerged structures. The transient elastic-plastic responses of the submerged stiffened plate to the transverse acoustic loads were predicted using EPSA and USA-STAGS computer codes. The tripping of stiffener and its effect to the gross shell response are the goal to achieve. Underwater explosion tests were performed and the data were correlated with the predictions. Professor Shin also conducted and investigation for NAVSEA to evaluate the effects of using primacord to remove a damaged conventional propeller from a waterborne surface ship. The relation between the shock wave pressure on the propeller and the primacord charge size was determined by experiments. The underwater tests were performed using a US Coast Guard cutter at San Diego, CA. The primacord shock induced responses of the shaft were also measured.

Professor Smith has been conducting research on investigating the application of optimal control theory to the control of robotic mechanism. An evaluation of candidate 'optimal' strategies will be conducted via dynamic simulation. The most promising strategy will be implemented in a computer based robot controller. The importance of key assumptions about nonlinear design performance will be investigated.

#### HEAT TRANSFER

Professor Culbreth has continued his investigation of turbulent buoyant jets in a crossflowing fluid. Using a microthermocouple probe and a Laser Doppler Velocimeter, he and his thesis students, have taken various measurements of the temperature and velocity fields of heated jets as they mix with the flowing stream.

Professor Kelleher has continued his investigation of natural convection phenomena in liquid enclosures. Using water as the test liquid, and the Baker

electrochemical technique of flow visualization, he has observed various flow patterns generated by a heated protrusion within the enclosure. Photographs of the flow patterns as well as measured Nusselt numbers have been obtained for various locations of the protrusion inside the enclosure.

Professor Marto, together with Adjunct Research Professor Wanniarchchi, have continued their studies of two-phase heat transfer phenomena. Under a National Science Foundation grant, they have been measuring enhanced steam condensation heat transfer coefficients on horizontal tubes. With the collaboration of Dr. John Rose of Queen Mary College, UK, a long term study is being made of both film condensation on finned tubes as well as dropwise condensation using ultra-thin organic coatings. The best enhancements so far (when compared to film condensation on smooth tubes) under vacuum conditions have been approximately 4 for film condensation on finned tubes and approximately 6-8 for dropwise conditions. Professor Marto has begun a new project to study the nucleate boiling behavior of R-114 from structured boiling surfaces. The influence of small oil concentrations upon enhanced boiling performance will be studied. An evaluation of single phase and two phase cooling techniques for use in electrical machinery has also been performed and recommendations have been made for needed research to enhance motor effectiveness.

#### HYDRODYNAMICS AND FLUID MECHANICS

Professor Culbreth, employing a pulsed-nitrogen laser and photochromic dye, investigated several flow fields. A small amount of dye has been injected into the flow and opaque traces have been generated by firing an ultraviolet laser beam through the fluid. The technique appears to be very valuable for the visualization of a flow field and for calculating the velocities along the path of the traces. The investigation resulted in two MS theses.

Professor Kelleher's research efforts have been dedicated to the computation of the flow over compliant surfaces. Through the use of spectral techniques, the flow characteristics, including surface pressure and shear distribution, have been calculated for turbulent flow over compliant surfaces. The work is still in progress and resulted in several papers.

Professor Pucci continued his long-range research on exhaust gas eductor design. The objectives of the investigation are to provide guidance in the design of an eductor system for the new Arleigh Burke class destroyer, to assist in the preparation of a contract for a full scale design of an eductor and to fabricate models for testing at NPS.

Professor Sarpkaya's research efforts dealt with a number of projects. The first is the study of the evolution of trailing vortices in homogeneous and density-stratified media. A series of experiments have been carried out in a long towing tank and the rise and demise of the trailing vortices generated by various lifting surfaces have been evaluated. The predictions of a parallel theoretical investigation have yielded results in surprisingly good agreement with those obtained experimentally. The work has resulted in various papers and student theses. The second investigation dealt with the yaw and current effects on smooth and rough cylinders in a harmonically oscillating flow. It has been shown that the effect of wake-biasing resulting from the current is very significant and the force-transfer coefficients obtained in the absence of current cannot be used to predict the forces acting on cylinders subjected to the combined flow field. Finally, Professor Sarpkaya has continued his long-range investigation on the discrete vortex simulation of separated time-dependent flows. Currently, the model is being applied to oscillating flow about a cylinder.

#### MATERIALS SCIENCE

Profesor Challenger continued his research during the first half of the year on elevated temperature fatigue and also on microstructural development in high strength steel weldments. Several thesis students and Adjunct Research Profesor Prabir Deb contributed to this work. Notable results were obtained in work on fatigue crack initiation as affected by environment for 2 1/4 Cr - 1 Mo steel, tested at 540°C. It was demonstrated that compressive holds in such testing resulted in greater degradation of fatigue life than tensile holds and this was attributed to cracking of oxides which were found in a stress-free state during the hold periods. In April 1984, Professor Challenger began leave from NPS to assume a position as Liaison Scientist for the Office of Naval Research, London. He will remain there throughout 1985 and will complete two years service at ONR-London in April, 1986.

Profesor Kassner's research is presently funded by the Naval Postgraduate School Foundation Research Program. There are two fundamental research areas. The first is the examination of the rate-controlling processes in the creep of Al and 304 stainless steel. The experiments consist of transmission electron microscope examination of specimens tested to large steady-state stains; in addition, Profesor Kassner is performing in situ cyclic tests in a high voltage electron microscope to examine the fundamental aspects of reversed deformations.

Profesor T. B. Massalski, NAVSEA Research Chair Professor for FY85, has initiated research in three general areas. In connection with the NAVSEA project on "quiet metals," an investigation of the damping properties of

certain martensitic alloys related to the shape memory effect is being conducted. This research is being done in cooperation with Professor Y. Shin and Professor J. Perkins of this department. Other research by Professor Massalski involves thermodynamic modeling of phase diagrams of several binary alloy systems and the general assessment and measurements of the glass-forming ability of selected alloys in ternary systems based on Cu, such as Cu-Ti-Zr, or Cu-Ag-Tu.

Professor McNelley has continued research into deformation processing and elevated temperature flow characteristics of high-Mg, Al-Mg alloys. This work has been sponsored by the Naval Air Systems Command. Recent work has demonstrated that thermomechanical processing by warm rolling develops a fine structure which is superplastic at relatively low temperatures and high strain rates when compared to other Aluminum alloys, and also deforms with minimal cavitation. This work has involved several thesis students as well as Adjunct Research Professor Eui-Whee Lee. Additional research efforts under Professor McNelley's guidance have included work on rolling contact fatigue behavior of 4-50 steel as influenced by processing history. A significant result has been the observation of porosity associated with the insoluble carbides of such a steel. This is thought to reduce fatigue life by assisting fatigue crack initiation and spall formation.

Professor Perkin's research continued on a National Science Foundation grant to investigate martensitic transformations in shape memory alloys. The main thrust of this research is to determine the mechanisms by which microstructural variables, such as grain size, dislocation substructure and vacancy concentration, affect the kinetics and morphology of the transformations. These questions are being approached mainly through the application of high-resolution transmission electron microscopic techniques. In this, the participation of Dr. Kenji Adachi as a research associate, has been invaluable.

Title: Structure and Performance of Platinum Modified Aluminide Coatings

Investigator: Donald H. Boone, Adjunct Research Professor

Sponsor: Office of Naval Research

Objectives: To understand the effects of noble metal additions to aluminide coatings, their structure, processing, and protectivity in high temperature hot corrosion and cyclic oxidation conditions.

A range of coating structures varying from single phase PtAl<sub>2</sub> through a two-phase PtAl<sub>2</sub>- $\beta$ (NiPt-Al) to the single phase  $\beta$ (NiPtAl) were found to exist in commercial coatings and procedures for producing these structures were established. Surface topology of the resulting coatings was found to be related to the selective interdiffusion of the Pt with the superalloy substrate. The effect of this rough surface on resulting oxide formation and adherence is under investigation. Hot corrosion testing of the various structures is in progress on 700° and 900°. Cyclic oxidation testing is being initiated.

Title: Cyclic Oxidation of Coated ODS MA Alloys

Investigator: Donald H. Boone, Adjunct Research Professor

Sponsors: International Nickel Company  
Naval Air Systems Command

Objective: To understand the coating substrate diffusional interactions which can produce Kirkendall porosity and premature coating spallation.

Summary: The effect of substrate composition and processing variables of high volume fraction gamma prime oxide dispersion strengthened alloys are being studied in cyclic oxidation exposure. Three archetype coating systems, a diffusion aluminide, and an EB-PVD and LPPS applied overlay NiCoCrAlY coating are being studied. Initial results are demonstrating both substrate and coating effects on diffusional interaction and propensity for porosity formation.

Title: C.A.E. (Computer Aided Engineering) with an  
APOLLO computer

Investigator: Giles Cantin, Professor of Mechanical  
Engineering

Sponsor: NPS Foundation Research Program

Objective: The APOLLO computer is a new breed of work  
station especially well adapted for C.A.E.  
applications. The GRAPHICS capabilities and  
computing power make it easy to use with many  
existing systems.

Summary: A graphics package was obtained from the DANFORD  
Corporation and installed in the machine. Then  
the GIFTS system was modified and is now running.  
Modifications were required in some 75  
subroutines.

Title: Thermal Mapping of Turbulent Buoyant Jets Using a Microthermocouple Probe

Investigator: William G. Culbreth, Assistant Professor of Mechanical Engineering

Sponsor: NPS Foundation Research Program

Objective: This is part of an ongoing research project involving a fundamental study of the properties of buoyant jets in a crossflowing fluid. An experimental facility has been developed that uses a Laser Doppler Velocimeter and a microthermocouple probe to measure temperature and velocity distributions in jets in a non-intrusive manner. Data that has been acquired includes the length of the zone of flow establishment based on turbulence and velocity data, and contour plots of velocity and temperature in heated jets.

Publication: W. G. Culbreth and J. P. Legoff, "Determination of the Length of the Zone of Flow Establishment in a Submerged, Axisymmetric Jet," in progress.

Theses Directed: M. D. Wessman, "Measurement of Velocity Distributions in Turbulent Jets Using a Laser Doppler Velocimeter," Master's Thesis, June, 1983.  
P. W. Nickodem, "Measurement of Velocity Distributions in Turbulent Jets in a Cross Flowing Ambient Fluid Using a Laser Doppler Velocimeter," Master's Thesis, June, 1984.  
R. J. Matoushek, "Design and Construction of a Computer Controlled Microthermocouple Probe for the Study of Buoyant Jets," Master's Thesis, September, 1984.

Title: Flow Visualization Using a Pulsed-Nitrogen Laser

Investigator: William G. Culbreth, Assistant Professor of Mechanical Engineering

Sponsor: None

Objective: To employ a pulsed-nitrogen laser and photochromic dye to determine flow fields. The technique is valuable for visualizing flows and to measure velocity distributions along traces created in a fluid.

Summary: Several fluid flows that result in very small velocities have been investigated through the use of the pulsed-nitrogen laser. The flow of a hydrocarbon can be investigated using this technique by dispersing a small amount of a photochromic dye in the fluid. By firing an ultraviolet laser beam through the fluid, opaque traces are introduced that deform due to the hydrodynamics of the flow field. The technique is valuable for visualizing the flow field and calculating velocities along the path of the traces.

Theses Directed: A. F. Pellin, "An Experimental Technique for the Study of Velocity Profiles in a Growing Droplet Using a Pulsed-Nitrogen Laser," Master's Thesis, March, 1982.

D. T. Armstrong, "An Experimental Technique for the Study of Velocity Profiles in a Laminar Jet Using a Pulsed-Nitrogen Laser," Master's Thesis, September, 1984.

Title: Development of Shape Memory Alloy Actuators for Robotics

Investigator: William G. Culbreth, Assistant Professor of Mechanical Engineering

Sponsor: None

Objective: To develop shape memory alloy actuators for use in robotics that employ liquid and gas forced convection cooling in lightweight enclosures.

Summary: A plexiglas enclosure was constructed to determine the transient response of shape memory alloy coils under various types of cooling and power input. Thermocouples were attached at three different points along the coils and at the inlet and outlet nozzles of the enclosure. The displacement of the actuator as a function of time was measured and the time constant of the coils were determined for various flow rates and cooling conditions. Results indicated that such enclosures can serve as insulators to decrease heat loss during actuation and as excellent coolers when return to the remembered shape is desired.

Conference Presentation: W. G. Culbreth and R. Watson, "Computer-Aided Data Acquisition from a Shape-Memory Alloy Robotic Actuator," ASME International Computers in Engineering Conference, in progress.

Thesis Directed: P. E. Watson, "Comparison of the Response of Shape Memory Alloy Actuators Using Air-Cooling and Water-Cooling," Master's Thesis, September, 1984.

Title: Natural Convection in a Liquid Filled Enclosure  
With a Heated Protrusion

Investigator: M. D. Kelleher, Professor of Mechanical  
Engineering

Sponsor: NPS Foundation Research Program

Objective: To determine the flow patterns, temperature  
distributions and heat transfer rates in the  
natural convection process from a heated  
protrusion in a liquid filled enclosure.

Summary: A flow visualization study of natural convection  
in a liquid filled rectangular enclosure with a  
small heater protruding into it from one vertical  
wall has been conducted. The top and bottom  
horizontal surfaces of the enclosure were heat  
exchangers whose temperature could be varied  
independently. The fluid in the enclosure was  
water. The Baker electrochemical technique,  
which utilizes a pH indicator, was used for flow  
visualization. Photographs have been taken of  
the flow patterns for several different locations  
of the heater on the vertical wall. Nusselt  
numbers for each heater location and for a range  
of Rayleigh numbers have also been determined.  
The data suggests a trend that, as the heater is  
raised within the enclosure, the Nusselt number  
decreases.

Theses Directed: Rick H. Knock, "Flow Visualization Study of  
Natural Convection From a Heated Protrusion in a  
Liquid Filled Enclosure," Master's Thesis,  
December, 1983.

Mason C. Redrix, "Flow Visualization of Natural  
Convection in a Narrow Rectangular Enclosure  
with a Heated Protrusion," Master's Thesis,  
September, 1984.

Title: Computation of the Flow Over Compliant Surfaces

Investigator: M. D. Kelleher, Professor of Mechanical Engineering.

Sponsor: Office of Naval Research

Objective: Use spectral techniques to numerically calculate the flow characteristics, including surface pressure and shear distributions, for turbulent flow over compliant surfaces.

Summary: The use of spectral methods has proven to be a very powerful tool for the analysis of flows over wavy or compliant walls. In this work spectral methods are being used to study the effects of compliant walls on turbulent flow drag. The first part of the work has been to extend the presently available laminar spectral code to include turbulent flow. To accomplish this, Cambridge Hydrodynamics, Inc. has developed a spectral code for the solution of the Navier-Stokes equations which incorporates a mixing length/eddy viscosity turbulence model. The code also incorporates the previously developed conformal mapping preprocessor to deal with the complex geometry associated with wavy walls.

Publication: M. D. Kelleher and R. Balasubramanian, "On the Use of Linearized Boundary Conditions in the Computation of Flow over Wavy Walls," Laminar Turbulent Boundary Layers, ASME Symposium Volume, FED Vol. 11, (1984).

Conference Presentation: M. D. Kelleher and R. Balasubramanian, "On the Use of Linearized Boundary Conditions in the Computation of Flow over Wavy Walls," ASME Energy Sources Technology Conference, New Orleans, Louisiana, February, 1984.

Title: High-Strength Aluminum-Magnesium Alloys: Thermo-mechanical Processing, Microstructure and Mechanical Properties

Investigator: T. R. McNelley, Associate Professor of Materials Science, Department of Mechanical Engineering.

Sponsor: Naval Air Systems Command

Objective: To study the development of microstructure by thermomechanical processing of high-Mg, Al-Mg alloys with particular emphasis on the influence of microstructural variables on the elevated temperature superplastic response of these alloys.

Summary: Thermomechanical processing by warm rolling at 300° C of Al-8 to 10% Mg alloys has been shown to result in moderate to high strength alloys of good ductility, fatigue and environmental resistance. Recent work has also clearly demonstrated that these alloys are superplastic at warm temperatures; ductility of 400% has been obtained in Al-10.2% Mg-0.5% Mn, tested at 300° C and  $\dot{\epsilon} = 2 \times 10^{-3} \text{ s}^{-1}$  in the warm rolled condition. Such behavior is remarkable in that most superplastic Al alloys do not develop such ductilities except at higher temperatures and lower strain rates. Of further note is that such warm rolled materials exhibit little cavitation whereas current superplastic Al alloys are severely limited in application due to this phenomenon. It has also been found that low-temperature annealing may enhance further the superplastic ductilities to > 800% and also that recrystallizing anneals (at temperatures above the Mg solvus, e.g., 400° C) suppresses superplasticity. This may have important implications in thermomechanical processing of current high-strength Al alloys such as 7475 wherein such treatments are employed. Recent work has demonstrated that Cu and Zr additions may be employed as well as Mn to result in enhanced elevated temperature ductility.

Publication: A. Garg and T. R. McNelley, "Development of Structure and Mechanical Properties in Al-10.2 Wt. Pct. Mg by Thermomechanical Processing," Scripta Metallurgical, Vol. 18, 1984, p. 917.

Conference  
Presentations:

T. R. McNelley and A. Garg, "Development of Microstructure and Mechanical Properties in Thermomechanical Processing of High Mg, Al-Mg Alloys," WESTEC-84, American Society for Metals and Society of Manufacturing Engineers, Los Angeles, CA, March 1984.

T. R. McNelley, "Development of Microstructure and Mechanical Properties in Thermomechanical Processing of High-Mg, Al-Mg Alloys," Naval Air Systems Command Program Review, NAVAIR Headquarters, Washington, D.C., September 1984.

T. R. McNelley and F. W. Lee, "Development of High Strength in High Mg, Al-Mg-X Alloys by Thermomechanical Processing," Annual Fall Meeting of The Metallurgical Society - AIME and ASM, Detroit, MI, September 1984.

E. W. Lee and T. P. McNelley, "Effects of Thermomechanical Processing of High-Mg, Al-Mg-X Alloys on Superplastic Behavior," Annual Fall Meeting of the Metallurgical Society - AIME and ASM, Detroit, MI, September 1984.

Theses Directed:

J. J. Becker, "Superplasticity in Thermomechanically Processed High-Magnesium Aluminum-Magnesium Alloys, Master's Thesis, March 1984.

M. E. Mills, "Superplasticity in Thermomechanically Processed Aluminum-10.2% Mg-0.52% Mn Alloy, Master's Thesis, September 1984.

Title: Application of a Thermomechanical Process for Refinement of Grain Size and Carbide Size to M-50 Bearing Steel

Investigator: T. R. McNelley, Associate Professor of Materials Science, Department of Mechanical Engineering.

Sponsor: Naval Air Propulsion Center and Air Force Wright Aeronautical Laboratory

Objective: To evaluate the influence of grain and carbide refinement by thermomechanical processing on the rolling contact fatigue behavior of M-50 steel.

Summary: The thermomechanical processing of this research consists principally of warm rolling to refine the size of precipitated carbides and to enhance grain refinement in the steel. Subsequent hardening heat treatments have been shown to result in coarsening of the structure and increase retained austenite unless conducted at lower heating temperatures for shorter heating times. When such reduction in time/temperature is done, the microstructural refinement induced by the warm rolling is retained in the steel. It is anticipated that this may result in enhanced rolling contact fatigue behavior in such a steel. It is recognized, however, that the structure of M-50 is complicated by the presence of insoluble carbides whose size is not greatly affected by the warm rolling of this research. Also, recent research has shown that some heats of M-50 may have porosity associated with these insoluble carbides. As such, experimental determination of rolling contact fatigue behavior will be conducted in the following year.

Publications: T. R. McNelley, M. R. Edwards, A. Doig and C. W. Schultz, "The Effect of Hardening and Tempering on the Structure and Properties of Warm-Rolled AISI 52100 Steel," in progress.

T. R. McNelley and A. Garg, "Evaluation of the Carbon Content of Martensite in AISI 52100 Steel as Influenced by Thermomechanical History Using X-ray Diffraction," in progress.

Thesis Directed: E. V. Bres, "The Heat Treatment Response of Thermomechanically Processed M-50 Steel," Master's Thesis, December 1983.

Title: Simulation and Synthesis of Electromechanical Actuators

Investigators: R. H. Nunn, Professor of Mechanical Engineering and A. Gerba, Associate Professor of Electrical Engineering

Sponsor: None

Objective: Development of Simulation and design codes for electromechanical actuators. Work is in support of the NWC program "Advanced Missile Control Devices."

Summary: A study was begun to model and simulate a missile fin actuation system driven by a brushless dc motor. This report describes preliminary results in which the motor, drive-train, and load were modeled using the usual linear descriptions. Simulation of system response to step and frequency inputs was accomplished using the Continuous System Modeling Program. Initial qualitative results show that the model successfully predicts the effects expected from variations in load and damping. Further evaluation of the model and possible refinements will require the availability of test data.

Publication: R. H. Nunn and K. J. Wright, "Modeling and Simulation of a Fin Actuation System," NPS Technical Report, NPS69-84-011, June, 1984.

Thesis Directed: K. J. Wright, "Simulation and Synthesis of an Electro-Mechanical Actuator," Master's Thesis, September, 1984.

Title: Martensitic Transformations in Shape Memory Alloys

Investigator: Jeff Perkins, Associate Professor of Materials Science

Sponsor: National Science Foundation

Objective: To examine the effect of microstructural parameters, such as parent phase grain size and dislocation substructure, on martensitic transformation morphologies and shape memory behavior.

Summary: Considerable progress has been made in the examination of martensitic microstructures after pre-deformation treatments. Effects on transformation kinetics have also been considered. High resolution TEM techniques have been developed to study the fine structure of martensitic microstructures.

Publications:

Jeff Perkins, "The Microstructure of Rapidly Solidified  $\beta$ -Phase Cu-Zn-Al Alloys," Metallurgical Transactions, 14A (1983), pp. 2229-2234.

Jeff Perkins and R. O. Sponholz, "Stress-Induced Martensitic Transformation Cycling and Two-Way Shape Memory 'Training' in Cu-Zn-Al Alloys," Metallurgical Transactions, 15A (1984), pp. 313-321.

Jeff Perkins, "Martensitic Transformation Cycling and the Phenomenon of Two-Way Shape Memory Training," Mat. Res. Soc. Symp. Proc., Vol. 21, (1984), pp. 669-674.

Jeff Perkins and Paul Bobowiec, "Microstructural Effects of Martensitic Transformation Cycling of a Cu-Zn-Al Alloy: Vestigial Structures in the Parent Phase," Metallurgical Transactions, forthcoming.

Kenji Adachi, Steve Sullivan and Jeff Perkins,  
"Deformation of Martensite in a Polycrystalline  
Cu-Zn-Al Alloy," Metallurgical Transactions,  
forthcoming.

Jeff Perkins, "Shape Memory Alloys," Encyclopedia  
of Science and Technology, 6th Edition, McGraw-  
Hill, N.Y., forthcoming.

Conference  
Presentation:

Jeff Perkins, "Martensitic Transformation  
Cycling and the Phenomenon of Two-Way Shape  
Memory Training," International Conference on  
Phase Transformations in Solids, Maleme-Chania,  
Crete, Greece, June 27, 1983.

Title: Exhaust Gas Eductor Design

Investigator: P. F. Pucci, Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: Assist NAVSEA in the design of exhaust gas eductors for gas turbine propulsion engines.

Summary: Guidance in the design of an eductor system for the new Arleigh Burke class destroyer. Assist in the preparation of a contract for a full size design of an eductor system for the Arleigh Burke class destroyer plus the fabrication of models for testing at NPS.

Title: Analytic Model of Gas Turbine Installations

Investigator: P. F. Pucci, Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: To develop an analytic model for computer use for the installation of a gas turbine propulsion engine aboard a naval ship.

Summary: An analytic computer simulation of marine gas turbine engine installations including intake air and exhaust gas ducting for the engine and for the engine module cooling air was developed. A one dimensional analysis was used in determining the pressure losses in the ducting. The pressure losses along with the ambient conditions and desired power setting define a unique operating point for the system. The computer model predicts the operating parameters by an iterative matching technique.

Thesis Directed: S. M. Ezzell, "An Analytic Model of Gas Turbine Installations," Master's Thesis, March, 1984.

Title: Trailing Vortices in Stratified Medium

Investigator: T. Sarpkaya, Distinguished Professor of Mechanical Engineering

Sponsor: DARPA

Objective: To perform experiments and analysis to determine the fluid-mechanical mechanisms which govern the rise and demise of trailing vortices in homogeneous and density-stratified media.

Summary: A series of experiments has been carried out with rectangular foils, delta wings, and axisymmetric bodies in stratified and homogeneous media at various angles of attack. The formation of the sinusoidal instability, the vortex breakdown, and the vortex rings has been quantified and expressed in terms of the Vaisala-Brunt frequency, stratification parameter, and the normalized time. Furthermore, the effect of the axisymmetric body on the trailing vortices generated by the control surfaces of the body has been evaluated both analytically and experimentally.

Publications:

T. Sarpkaya, "The Rise and Demise of Trailing Vortices in Homogeneous and Density-Stratified Media," Proceedings of the International Conference on Advanced Topics in Aerodynamics and Aeroacoustics, Springer-Verlag, (1983), pp. 1-3.

T. Sarpkaya, "Trailing Vortices in Homogeneous and Density-Stratified Media," Journal of Fluid Mechanics 136, (November, 1983), pp. 85-109.

T. Sarpkaya, "Effect of Core Size on the Rise and Demise of Trailing Vortices," NPS Technical Report, NPS-69-82-010, December, 1982.

T. Sarpkaya and D. O. Henderson, "Surface Disturbances due to Trailing Vortices," NPS Technical Report, NPS-69-84-004, March, 1984.

Thesis Directed: Dwight O. Henderson, Jr., "Surface Disturbances due to Trailing Vortices," Master's/Engineer's Thesis, March, 1984.

Title: Yaw and Current Effects on Hydrodynamic Resistance of Cylinders

Investigator: T. Sarpkaya, Distinguished Professor of Mechanical Engineering

Sponsor: National Science Foundation

Objective: To determine the lift, drag, and inertia coefficients for smooth and rough circular cylinders in yaw and current in a harmonically oscillating flow and to carry out a discrete vortex analysis of the separated time-dependent flow.

Summary: Experiments have been carried out with smooth and sand-roughened circular cylinders in harmonically oscillating flow in a large U-shaped water tunnel. The force transfer coefficients have been determined for various angles of yaw. The results have shown that the flow about each cylinder is unique and the independence principle (cosine law) does not hold true over the range of Reynolds numbers and Keulegan-Carpenter numbers investigated. Furthermore, the pressure distribution has been measured about smooth and rough cylinders and the results have been related to the evolution of the vortices. The discrete vortex model has been considerably improved and the analytical predictions of the behavior of impulsively started flow have been shown to be in excellent agreement with those obtained experimentally. Additional work is underway to extend the analysis to harmonically oscillating flows.

Publications:

T. Sarpkaya and I. Cakal, "A Comprehensive Sensitivity Analysis of the OTS Data," Proceedings of the Offshore Technology Conference, Vol. 1, (1983), pp. 317-326.

T. Sarpkaya, "Oscillating Flow About Yawed Cylinders," NPS Technical Report, NPS-69-83-001, March, 1983.

T. Sarpkaya, "Discussion of Quasi 2-D Forces on a Vertical Cylinder in Waves," Journal of Waterway, Port, Coastal, and Ocean Engineering, ASCE, Vol. 110, No. 1, (February 1984), pp. 120-123.

T. Sarpkaya and John R. Wilson, "Pressure Distribution on Smooth and Rough Cylinders in Harmonic Flow," Proceedings of the Ocean Structural Dynamics Symposium '84, (1984), pp. 341-355.

T. Sarpkaya and Michael Storm, "Hydrodynamic Forces from Combined Wave and Current Flow on Smooth and Rough Circular Cylinders at High Reynolds Numbers," Proceedings of the Offshore Technology Conference, OTC-4830, (May, 1984).

Thesis Directed: Michael Storm, "Wave and Current Induced Forces on Cylinders," Master's/Engineer's Thesis, June, 1984.

Title: Underwater Shock Response of Submerged Structure

Investigator: Y. S. Shin, Associate Professor of Mechanical Engineering

Sponsors: Defense Nuclear Agency and NPS Foundation Research Program

Objective: (1) To look into the insight of the large deflection elastic-plastic transient response characteristics of submerged structures in the transient acoustic shock loading condition, (2) to perform underwater explosion testing using stiffened plates and to validate the predicted results with that of the experiments, and (3) to evaluate shipboard equipment response to underwater explosion

Summary: The transient elastic-plastic responses of the submerged stiffened plate to the transverse acoustic loads were predicted using EPSA and USA-STAGS codes. The tripping of stiffener and its effect to the gross shell response are the goal to achieve. The types of the stiffeners include rectangular, T-type and Z-type stiffeners. The underwater explosion testing was performed using the stiffened plate and the test data were correlated with the EPSA and USA-STAGS calculation. The test site is the West Coast Shock Test Facility at Hunter's Point Naval Shipyard located south of San Francisco, CA.

Publications: T. R. Pentz and Y. S. Shin, "On the Field Experiences of INDEX Testing for a Stiffened Flat Plate Model," Shock and Vibration Bulletin, forthcoming.

M. S. Welch and Y. S. Shin, "Numerical Analysis of the Underwater Shock-Induced Responses of Submarine Installed Equipment," Shock and Vibration Bulletin, forthcoming.

Conference Presentations:

T. R. Rentz and Y. S. Shin, "On the Field Experiences of INDEX Testing for a Stiffened Flat Plate Model," 55th Shock and Vibration Symposium, Dayton, OH, October, 1984.

M. S. Welch and Y. S. Shin, "Numerical Analysis of the Underwater Shock-Induced Responses of Submarine Installed Equipment," 55th Shock and Vibration Symposium, Dayton, OH, October, 1984.

F. G. Dauhe and Y. S. Shin, "Postprocessing of INDEX Responses of Submerged Cylindrical Shell Using PATRAN-G," 2nd PATRAN Users Conference, Newport Beach, CA, May 21-22, 1984.

Theses Directed:

F. G. Dauhe, "Underwater Shock-Induced Responses of Submerged Cylindrical Structures," Master's Thesis, December, 1983.

M. K. Asada, "An Analytical Evaluation of Spall Suppression of Impulsively Loaded Aluminum Panels Based on a One Dimensional Stress Wave Propagation Model," Master's Thesis, March, 1984.

J. Lee, "Nonlinear Transient Response of Flat Plate to Air Shock Wave," Master's Thesis, December, 1983.

M. S. Welch, "Numerical Analysis of the Elastic Shock Response of Installed Submarine Equipment," Master's Thesis, June, 1984.

T. R. Rentz, "An Experimental Investigation into the Dynamic Response of a Stiffened Flat Plate Loaded Impulsively by an Underwater Shockwave," Master's Thesis, June, 1984.

N. R. King, "Underwater Shock-Induced Responses of Stiffened Flat Plates: An Investigation into the Predictive Capabilities of the USA-STAGS Code," Master's Thesis, September, 1984.

Title: Damping Measurement and Modal Analysis  
Conducted at Low Stress Level and High Frequency  
Range with Temperature Variations

Investigator: Y. S. Shin, Associate Professor of Mechanical  
Engineering

Sponsor: David W. Taylor Naval Ship Research and  
Development Center

Objective: To design a test procedure and to perform modal  
testing to measure the damping of the plate  
specimen at low stress level and high frequency  
range with temperature variations.

Summary: The test procedure including measurement  
technique and modal testing to measure the  
damping of naval materials has been developed by  
the Naval Postgraduate School. Test plates of  
desired materials include conventional naval  
materials and high damping materials such as  
constrained layer damped specimen. The  
conventional naval materials include Cast-Nickel  
Aluminum Bronze, Cast Manganese Bronze, Aluminum  
and HY-130 steel. Actual testing and  
verification of procedures are being conducted  
using the HP-5451C FFT analysis system. Impulse  
hammer technique and the random excitation method  
are used for the evaluation of the damping  
capacity or loss factor. Sensitivity studies are  
being performed to evaluate how various  
parameters affect the damping such as boundary  
conditions, size of specimen, sensor mounting  
method bubble effect, etc.

Publications: S. T. Knouse, P. F. Milster and Y. S. Shin,  
"Damping Measurement by Modal Analysis Conducted  
at Low Stress and High Frequency with Temperature  
Variations," NPS 69-84-002, Naval Postgraduate  
School, Monterey, CA, March, 1984.

P. F. Milster and Y. S. Shin, "Effect of  
Temperature and Environmental Changes on the  
Damping Properties of Randomly Excited Metal  
Plate Specimens," NPS 69-84-007, Naval  
Postgraduate School, Monterey, CA, September,  
1984.

Conference  
Presentations:

S. T. Knouse, P. F. Milster and Y. S. Shin,  
"Effect of Boundary Conditions on the Damping  
Characteristics of a Randomly Excited Cast Nickel  
Aluminum Bronze Specimen at Low Stress Levels,"  
accepted for presentation at the 3rd  
International Modal Analysis Conference, Orlando,  
FL, January 28-31, 1985.

P. F. Milster and Y. S. Shin, "Effect of  
Temperature on the Damping Characteristics of  
Randomly Excited Metal Plate Specimens in a Salt  
Water Environment," accepted for presentation at  
the 3rd International Modal Analysis Conference,  
Orlando, FL, January 28-31, 1985.

P. F. Milster and Y. S. Shin, "The Acoustic  
Damping Characteristics of a Randomly Excited  
Metal Plate Specimen in Air and Water  
Environments," accepted for presentation at the  
55th Shock and Vibration Symposium, Dayton, OH,  
October, 1984.

NOTE: A. R. Paladino (NAVSEA, 55X42, Head of  
Acoustic Engineering Branch) made a strong  
recommendation not to present "The Acoustic  
Damping Characteristics of a Randomly Excited  
Metal Plate Specimen in Air and Water  
Environments," since this sponsored research is  
directly related to the ship silencing  
application. As a result, all three  
papers cited above have been withdrawn.

Thesis Directed:

S. T. Knouse, "Effect of Boundary Conditions on  
the Damping Characteristics of a Randomly Excited  
Cast Nickel-Aluminum Bronze Specimen at Low  
Stress," Master's Thesis, March, 1984.

Title: Investigation into the Effects of Using Primacord to Remove a Damaged Conventional Propeller from a Waterborne Surface Ship

Investigator: Y. S. Shin, Associate Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: To perform experimental and numerical analyses to investigate primacord shock induced responses of the shaft, the stress wave propagation, and the potential damage to mechanical components.

Summary: The relation between the shock wave pressure on the propeller and the primacord charge size was determined by the experiments. The test was performed underwater using a US Coast Guard cutter at San Diego, CA. The primacord shock induced responses of the shaft were also measured.

Thesis Directed: J. H. Strandquist III and Y. S. Shin,  
"Investigation into the Effects of Using Detonating Cord to Remove a Conventional Propeller from a Waterborne Surface Ship,"  
Master's Thesis, December, 1984.

Title: Optimal Control of Robotic Mechanisms

Investigators: D. L. Smith, Associate Professor of Mechanical Engineering and G. J. Thaler, Distinguished Professor of Electrical Engineering

Sponsor: NPS Foundation Research Program

Objective: To investigate the application of optimal control theory to the control of robotic mechanisms.

Summary: Modern optimal control theory is well suited to computer based controller design. An evaluation of candidate 'optimal' strategies will be conducted via dynamic simulation. The most promising strategy will be implemented in a computer based robot controller. The importance of key assumptions about nonlinear design performance will be investigated.

Thesis Directed: G. R. McGalliard, "A General Simulation Program for Robot Manipulator Arm Dynamics," Master's Thesis, September, 1984.

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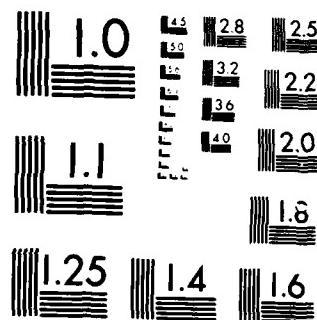
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